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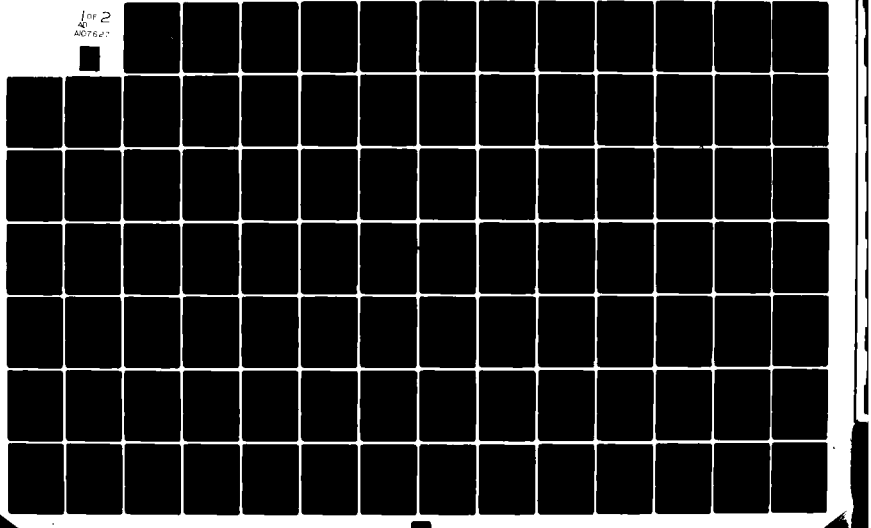

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Analytical modelling of creep response phenomena of human and rhesus monkey intervertebral discs subjected to a constant axial compressive load was performed by utilizing Kelvin-solid models. Results for the three and four-parameter models were excellent with an average error for the model predicted strain values from the experimental data ranging from .465% to 11.4% (collective average of 2.314%) for the former model and 1.29% to 19.9% (collective ranging from .465 for the latter on the 47-human spinal segments

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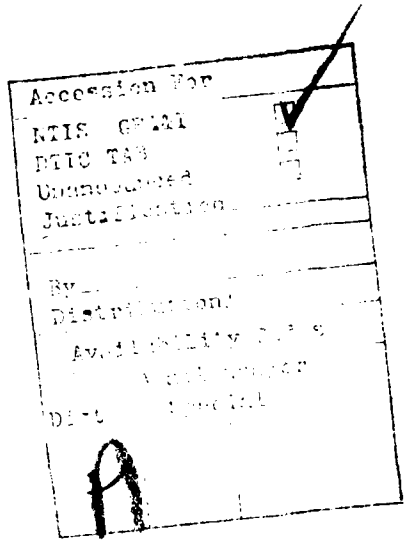

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Final Research Report

for

AFOSR- [redacted] 80-0115

entitled

ANALYTICAL MODELLING OF LOAD-DEFLECTION BEHAVIOR OF INTERVERTEBRAL DISCS SUBJECTED TO AXIAL COMPRESSION BY EXACT PARAMETRIC SOLUTIONS OF KELVIN-SOLID MODELS

by

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ABSTRACT

Results of analytical modelling of creep response phenomena of human and rhesus monkey intervertebral discs subjected to a constant axial compressive load by utilizing Kelvin-solid models are presented. Experimental datum from forty-seven human intervertebral joints were analyzed by 2-, 3-, and 4-parameter-solid models employing the Burns-Kaleps "exact analysis scheme". Results for the three and four-parameter models were excellent with an average error for the model predicted strain values from the experimental data ranging from .465% to 11.4% (collective average of 2.31%) for the former model and 1.29% to 19.9% (collective average of 4.44%) for the latter on the 47-human spinal segments considered. The 3-parameter model strain predictions were very nearly a "best fit" to the experimental data, while the values for the mechanical properties (Young's moduli and viscosity coefficients) of the 4-parameter model were obviously not optimized to the observed data. In spite of the "lack of optimization", the results suggest the latter model as being more appropriate for predicting compressive creep behavior of human spinal segments over the entire time range. Experimental datum from 59-rhesus monkey intervertebral joints were also analyzed, but by only the 2-parameter-solid model. Results were mixed with the average error per specimen ranging from 1.55% to 35%, but by comparison with the same model predictions for the human datum, the results clearly indicate superior results should be obtainable by a 3-parameter-solid model analysis. Consequently, correlation of the mechanical properties and spinal behavior of human and rhesus monkey specimens appears possible, which should allow dynamic vertical acceleration tests on rhesus monkey specimens to give valuable behavior probability data on human spinal columns.

RESEARCH AREA AND OBJECTIVES

An understanding of the mechanical properties and behavior of the spinal column is of general interest to a variety of researchers. Of particular interest to this investigation and the AFOSR is the biomechanical modelling of human and rhesus monkey intervertebral joint response to constant axial compressive loads, where an intervertebral joint is taken to be a spinal disc and adjoining vertebrae. Nachemson (1960), Hirsch (1965), and Rolander (1966) performed experimental investigations to determine the load-deflection behavior of the intervertebral disc subjected to axial loading. Kazarian (1975) reported creep characteristics for human spinal segments subjected to a constant axial stress, where the typical experimental data of strain $\epsilon(t)$, as illustrated by the dotted curve in Fig. 1, was observed to exhibit behavior similar to that of a Kelvin solid. Capitalizing on this observation, Kazarian and Kaleps (1979) illustrated the determination of Young's moduli and a viscosity coefficient for a three-parameter-solid model based on Kazarian's (1975) data. Their method of analysis, which employed various approximations and optimization schemes, was recently displaced by a more accurate and successful "exact analysis scheme" by Burns and Kaleps (1980). The latter scheme allowed for unique model identification by employing exact parameter solutions for the one-Kelvin-unit model, the three-parameter-solid model, and the two-Kelvin-unit model, with an illustrated method by which the associated Young's moduli and viscosity coefficients for an identified model are calculable.

The research supported by Grant No. AFOSR-80-0115 has been concerned with the modelling of compressive creep phenomena of human and rhesus monkey intervertebral joints that are subjected to a constant axial loading. The creep behavior of experimental strain data reported in the literature by Leon E. Kazarian (BED Branch Chief, Wright-Patterson Air Force Base) and others prompted the development of the "exact analysis scheme" by Marshall L. Burns in close collaboration with Ints Kaleps (BED Branch Chief, Wright-Patterson Air Force Base,, which constituted the theoretical basis for this investigation. The scheme employs exact parametric solution equations for the two-, three-, four-, and five-parameter-solid models in analyzing

Kazarian's human and rhesus monkey experimental data, resulting in the most appropriate model of the four being identified for the data associated with a particular intervertebral joint. Most importantly, the method allows for the determination of the mechanical properties (Young's moduli and viscosity coefficients) associated with an "identified model", once the values for the "model parameters" are uniquely determined from the experimental strain data of a particular spinal segment.

The general objectives of the research were to refine previously developed (Grant No. AFOSR-78-3578) computer programs concerned with the smoothing and interpolation of experimental strain data, and to reformulate and employ computer programs representing the "exact analysis scheme" for the four previously indicated solid-models on all of Dr. Leon E. Kazarian's human and rhesus monkey experimental data. Specifically, prior to its inception on March 1, 1980 the original research embodied the following activities:

(a) refine the computer programs utilized to smooth and interpolate Kazarian's experimental strain data,

(b) reformulate a unified modelling theory associated with the Burns-Kaleps "exact analysis scheme" for the 2-, 3-, 4-, and 5-parameter-solid models,

(c) chain the necessary computer programs for the 2-, 3-, 4-, and 5-parameter-solid models for the quick and efficient analysis of experimental data,

(d) initiate the smoothing, interpolation, and analysis computer programs on Kazarian's human strain data,

(e) initiate the loading of Kazarian's experimental data from rhesus monkey spinal segments into computer files,

(f) submit all available modelling results to Ints Kaleps and Leon E. Kazarian during a mid-August meeting at Wright-Patterson Air Force Base in Dayton, Ohio,

(g) complete the modelling analysis on all available experimental data by mid-December,

(h) submit all modelling results and discuss the research progress with Ints Kaleps and Leon E. Kazarian at our annual meeting in December at WPAFB in Dayton, Ohio,

(i) prepare research publications for the Journal of Biomechanics (Burns, Kaleps, and Kazarian) and the Journal of Biomechanical Engineering (Burns and Kaleps),

(j) prepare final research report for the AFOSR.

Although continuous effort was expended and steady progress maintained towards the timely completion of the research activities, it was obvious by mid-November that these objectives were overly optimistic for the originally granted twelve-month time frame. This was the result in part from two major modifications of the original proposal and progress was further inhibited from October through mid-January by several unanticipated developments.

GRANT MODIFICATIONS AND RESEARCH ENCUMBRANCES

The intent of the original proposal was modified in two significant ways, including (1) computer equipment and (2) experimental data format. With regards to the first modification, the principal investigator's letter dated 19th February, 1981 requested the purchase of a TRS-80 Model II micro-computer system, which would be utilized in the "computer analysis" of Dr. Kazarian's experimental strain data. This equipment was intended to reduce the research dependence on Tuskegee Institute's HP-2000 system and minimize that system's costs for "terminal time sharing" and "programs/data files storage". The TRS-80 Model II system, including a peripheral printer and acoustic coupler, was functional by late June and has been found completely capable of satisfing the original objectives detailed in the afore mentioned "request letter".

The second significant modification of the proposed research effort involved the "format" of the available experimental data. It was assumed in the original proposal that Dr. Kazarian's experimental strain datum for approximately 400 intervertebral joints were available on IBM computer cards, as was the situation for the effort supported by Grant No. AFOSR-78-3578A. Unlike the previous research, where the experimental strain data could be immediately loaded into a data-file on an HP-2000 disk via a card-reader, the "new" experimental data was available in digital form on "thermal printer rolls", which necessitated it being hand-typed into the Model II system and programmatically stored in appropriate data-files. Obviously, the availability of the experimental datum on computer cards was essential for the [illegible] completion of the research objectives, as the "time alloted" for data entry

was minimal in the original proposal. This unexpected "data format" was further frustrated by not having the "area data" associated with the time-deformation data for the sixty rhesus monkey spinal segments. In fact it was mid-April before the "area data" was available for inclusion with the time-deformation datum. It should be understood that the "exact analysis scheme" utilizes the "area data" in predicting the "mechanical properties" of a spinal segment, once a particular model is identified from the analysis of the experimental strain data.

Essentially, there were four significant delays in the research progress through mid-January, which resulted from the following:

(1) unavailability of the funded one-sixth release time for a computer assistant during the spring, 1980 semester,

(2) unanticipated time-demands required by the new equipment (Model II system) purchase and the incompatibility of the HP-2000 and the TRS-80 Model II BASIC computer languages,

(3) increased time-demands resulting from the "format" of Dr. Nazarian's rhesus monkey experimental strain datum,

(4) unavailability of the funded one-third release time for the principal investigator during a large portion of the fall, 1980 semester.

Each of these delays and their consequential impact on the research effort were fully discussed in the December 3rd, 1980 "Progress Report and Time Extension Request" and, as such, will not be detailed herein. However, one additional objective stated in that request, which was not contained in the original proposal, is indicated below for completeness:

(5) develop and implement a computer program on the TRS-80 Model II system for "optimizing" the values of the mechanical properties predicted by any one of the four solid-models.

RESEARCH PROGRESS AND RESULTS

Although the above time-delays impeded the research accomplishments on items [illegible] of the original objectives, all other objectives were successfully completed. After recognizing the inhibiting effect of the "format" of Dr. Nazarian's [illegible] experimental strain data, the modelling efforts were reduced to the analysis of the strain from 47-human and 59-rhesus monkey intervertebral joints.

The research accomplishments on these "two sets of data" will be detailed separately, as the human intervertebral joint data was fully analyzed on the HP-2000 system, while the rhesus monkey data was initiated for analysis on the TMS-80 Model II system.

Three remote terminals of the HP-2000 system were simultaneously utilized in analyzing the human experimental data and displaying the results (chained analysis programs involving the two-, three-, and four-parameter solid models; programatic plot involving error analysis of the experimental and model (2, 3, 4) predicted strain-time values; real time plot of original and model (2, 3, 4) predicted strain-time values) for each set of experimental strain data of the 47-human intervertebral joints. Superior results were obtained from this effort and are partially illustrated in Tables I, II, III, and IV. Table I simply offers an overview of the prediction capability and accuracy of the three models for each of the 47-human spinal segments. Table II clearly illustrates the ineptness of the two-parameter-solid model (one-Kelvin-unit) in predicting the observed compressive creep behavior, even though four spinal segments (I.D. No. 2, 8, 53, and 56) had acceptable average errors of 5% or less. It should be noted that the "average of the absolute percent error", denoted as AVERAGE ABS (% ERROR) in the tables, is defined in terms of the experimental, $\epsilon(t_i)_{exp}$, and model predicted, $\epsilon(t_i)_{cal}$, strain values as

$$\xi = (1/N) \sum_{i=1}^{N} ABS\left\{10^2 \cdot [\epsilon(t_i)_{exp} - \epsilon(t_i)_{cal}]/\epsilon(t_i)_{exp}\right\},$$

where N is the number of experimental data values. As can be seen in the real-time plots comparing the experimental compressive creep response for the 47-human intervertebral joints, by Kazarian, with the two-parameter-solid model predictions by the Burns-Kaleps exact analysis scheme (six 141-page copies of these real-time plots accompany this report under separate cover), the model is incapable of closely predicting the initial behavior of the experimental strain-time response. It is for this reason that the average % error is excessive, although some improvement is obviously possible by employing an "optimization scheme" on the model parameters.

The three-parameter and four-parameter-solid models yielded superior modelling

results, as is illustrated by Tables III and IV, respectively. As observed in Table III, the three-parameter-solid model yields calculated strain values that have collectively an average error of 8.31% from the experimentally measured (Kazarian) values for the 47-human intervertebral joints; whereas, the four-parameter-solid model (Table IV) illustrates a collective average error of 4.46%. It should be emphasized that in "general" the four-parameter model is capable of predicting the entire range of experimental strain values better than the three-parameter model. This is quickly perceived by viewing Figure I (or the real-time plots under separate cover) and realizing that the three-parameter-solid model (3PSM) values are essentially "optimized"; whereas, the values representative of the four-parameter-solid model (4PSM) are not optimized. Most importantly, however, the four-parameter model is capable of predicting the observed strain-time behavior at values of time that are close to t = 0, while by design the three-parameter model is seriously lacking in this predictability. It should be noted that the research supported by Grant No. AFOSR-78-3578A, on which the Burns and Kaleps (1980) publication was based, was only partially successful in modelling Kazarian's (1975) human intervertebral joint data. In fact the two-parameter and four-parameter-solid models were completely unsuccessful during that effort, while the three-parameter-solid model yielded good results on only twenty of the forty-seven human spinal segments. The effort expended during the current research investigation on improving the "smoothing", "interpolation", and "modelling" computer programs is primarily responsible for the superior results obtained. It bears stating that an average absolute-percent-error of approximately 2% (as defined by the above equation) is exceptionally good, since the observed strain-time data probably has as large or greater experimental error.

The modelling of the 59-rhesus monkey spinal segments (identified in Table V) was initiated on the TRS-80 Model II system. Due to the "time-delays" and unavailable "gaps data" as discussed previously, the analysis effort was continuously delayed and ultimately inhibited by the "lack of grant supported" release time for the principal investigator. The analysis at this time is only partially completed,

as only the two-parameter-solid model has been utilized. The computer results for this model are fully illustrated in Table VI for the 59-rhesus monkey spinal segments with mixed but encouraging predictions. The data represented in Table VI is "grouped" together for each of the 59-specimens, with the first line identifying the experimental spinal segment. In the first group of results per specimen, A1 and B1 are the "model parameters" predicted by the Burns-Kaleps "exact analysis scheme" (detailed in the Burns and Kaleps (1980) publication), while E1 and N1 (CGS units) are the model predicted material properties (Young's modulus and viscosity coefficient, respectively). The number of experimental "creep" data points analyzed is represented by N, while T1 and T2 represent the initial and final times (in minutes) for the data range. R1 is the AVERAGE % ERROR, R2 is the AVERAGE ABS (% ERROR), and in this context R1 indicates the "goodness of fit" while R2 represents the "quality of fit". Ideally, R1 would be very close to zero and R2 would be less than 5%, if the model is appropriate for the experimental data analyzed. Whereas the "first group" of results per specimen is representative of the "model predictions", the "second group" illustrates the "optimization" of the 1st group's model parameter values A1 and B1 (and hence the mechanical properties E1 and N1). These results clearly illustrate the advantage of the "exact analysis scheme" in that the values of the mechanical properties predicted by the model analysis are very close to the "optimized" values. The results are most encouraging and surprising because twenty-four of the 59 spinal segments analyzed yielded results under 10% for the AVERAGE-ABSOLUTE % ERROR, with nine of these being 6% or less. Clearly, the two-parameter-solid model is appropriate for RN57, since the AVERAGE-ABSOLUTE % ERROR over all of the data points is only 1.55%. By comparing the results of Table VI with those obtained by the same model for the 47-human spinal segments (Table II), it appears that a correlation is possible between human and rhesus monkey spinal behavior and that the three-parameter-solid model should yield superior results for all of the rhesus monkey data. Unfortunately the analysis results utilizing this model are not available, as the research release time for the principal investigator has expired without a continuation of grant support.

In fact the results detailed herein for the two-parameter-solid model were obtained by the principal investigator after the grant expiration date of May 14, 1981. The complete analysis of the Mazarian experimental strain datum for the 5 rhesus monkey intervertebral joints will be finished in the near future, at which time the results will be made available to the "concerned parties" at Wright-Patterson Air Force Base in Dayton, Ohio.

RESEARCH PRESENTATIONS AND PUBLICATIONS

The following presentation and publication have occurred during the past year:

> "Simulating Compressive Creep Phenomena of Intervertebral Discs Under Axial Loading by Exact Parametric Solutions of Kelvin-Solid Models", M. L. Burns, Review of Air Force Sponsored Research in Environmental Physiology and Biomechanics, 23-25 Sept., 31 (1980).
>
> "Analysis of Load-Deflection Behavior of Intervertebral Discs Under Axial Compression Using Exact Parametric Solutions of Kelvin-Solid Models", M. L. Burns, I. Kaleps, J. Biomechanics, 13/11, 959 (1980).

The details of the articles cited below are "nearly" completed and will be submitted for publication in the year indicated. Collectively, they will represent a very definitive resource in this area of research, becoming primary references for other investigators in related areas.

> "Analysis of Load-Deflection Behavior of Human Intervertebral Discs Under Axial Compression Using Exact Parametric Solutions for the 2-, 3-, and 4-Parameter-Solid Models", M. L. Burns, I. Kaleps, L. E. Mazarian, J. Biomechanics, (submission pending), (1981).
>
> "Analysis of Compressive Creep Behavior of Rhesus Monkey Intervertebral Discs Subjected to Axial Loading Using Exact Parametric Solutions for the 2- and 3-Parameter-Solid Models", M. L. Burns, I. Kaleps, L. E. Mazarian, J. Biomechanics, (submission pending), (1982).
>
> "Analytical Modelling of Compressive Creep Phenomena Using Exact Parametric Solutions of Kelvin-Solid and Maxwell-Fluid Models", M. L. Burns, I. Kaleps, J. Biomechanical Engineering, (submission pending), (1982).

CONCLUSION

The research effort expended and the progress attained by the principal investigator on Grant No. AFOSR-80-0115B has been presented along with alluding remarks [illegible] and unanticipated delays. The investigation has truly yielded exterior modelling results, but in addition it is the only

investigatory effort known to date that has successfully modelled creep response datum of human spinal segments by a four-parameter-solid model. The results tend to suggest that the four-parameter model and the mechanical properties calculated thereby are more appropriate than those predicted by the "celebrated" three-parameter-solid model for human spinal segments. Although the analysis results for the rhesus monkey datum are incomplete, the results illustrated from the two-parameter-solid model are most encouraging. The three-parameter-solid model analysis of rhesus monkey datum is expected to yield excellent results, thereby allowing a correlation of the mechanical properties and spinal behavior between human and rhesus monkey specimens. These results add considerable support to the continuation of this research effort and the continued utilization and development of the Burns-Haleps "exact analysis scheme" in modelling the creep behavior of experimental datum from biological tissues (bone, ligaments, spinal segments, and tendons).

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Kazarian, L. E. and Haleps, I. (1979) Mechanical and physical properties of the human intervertebral joint, Air Force Aerospace Medical Research Laboratory, AMRL-TR, Vol. 3, 1-25.

Nachemson, A. (1960) Lumbar intradiscal pressure, "Acta. Orthop. Scand., Suppl." 43, 9-104.

Rolander, S. D. (1966) Motion of the lumbar spine with special reference to stabilizing effect of posterior fusion, "Acta Orthop. Scand., Suppl." 90.

Figure I

A comparison of the experimental compressive creep response for the human T7 - T8 intervertebral joint, by Kazarian, with the predictions of a three-parameter-solid model (3PSM) and a four-parameter-solid model (4PSM), by the Burns-Kaleps exact analysis scheme.

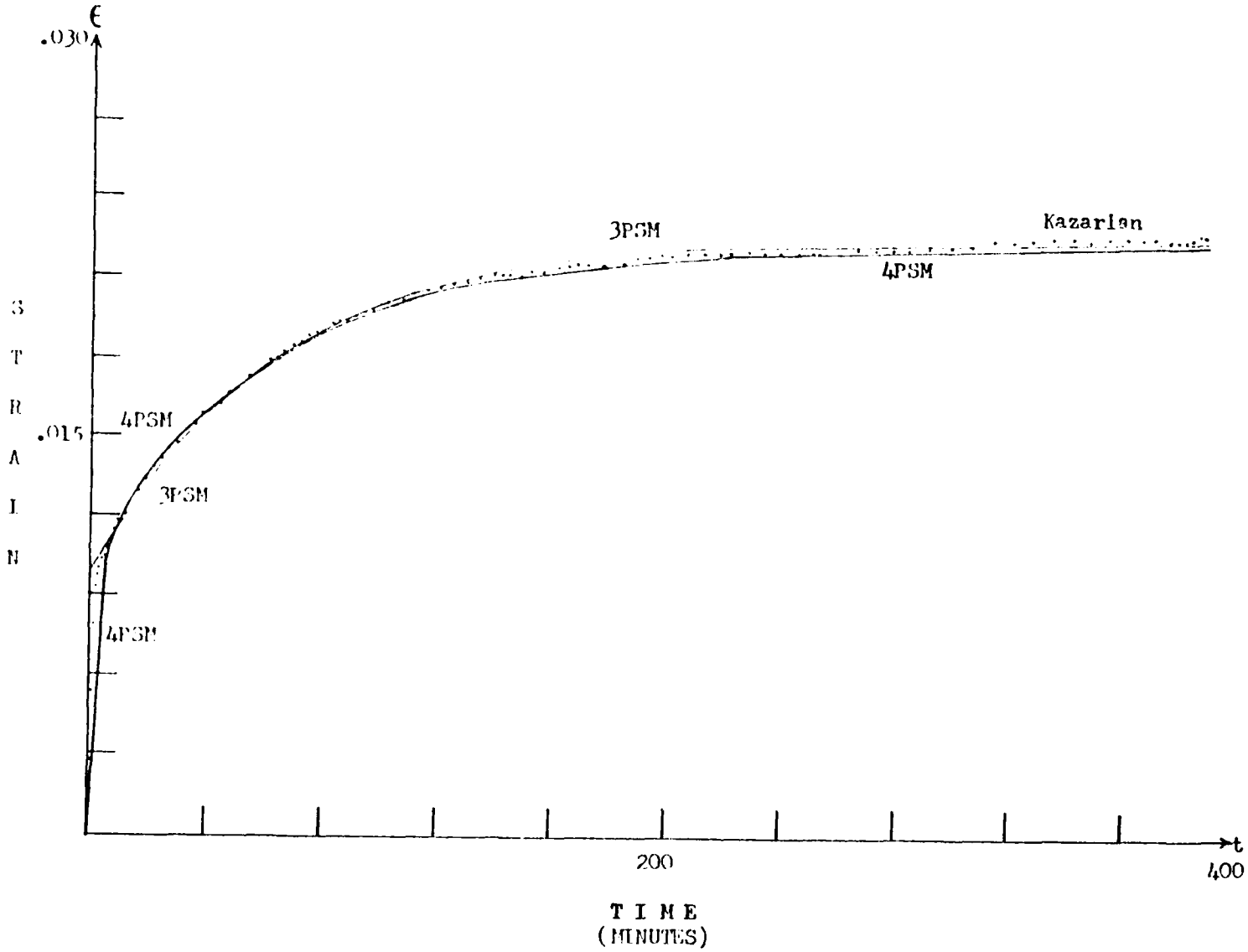
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Table I

A comparison of the 2-, 3-, and 4-parameter-solid models in their ability to predict Kazarian's experimental datum for 47 human intervertebral joints.

Comparison of the 2-, 3-, and 4-Parameter-Solid Models

Test I.D. No.	Spinal Segments	AVERAGE ABS(% ERROR) 2-Parameter Model	3-Parameter Model	4-Parameter Model
1	T1 - T2	19.92	4.840	4.440
2	T2 - T3	5.735	.6767	3.572
4	T4 - T5	12.15	2.418	3.980
5	T5 - T6	11.99	.9041	1.473
6	T6 - T7	15.66	2.345	4.194
7	T7 - T8	11.81	1.913	2.372
8	T8 - T9	5.510	2.420	10.51
9	T9 - T10	25.52	2.009	6.044
10	T10 - T11	14.56	1.603	4.405
16	T2 - T3	19.28	11.35	6.953
17	T3 - T4	13.15	1.265	6.212
18	T4 - T5	15.80	1.721	3.029
19	T5 - T6	19.51	1.830	5.649
20	T6 - T7	18.87	1.452	3.148
21	T7 - T8	19.85	2.457	4.834
22	T8 - T9	18.89	1.604	2.634
23	T9 - T10	19.02	1.805	3.136
24	T10 - T11	20.82	1.647	2.527
25	T11 - T12	17.09	1.383	3.518
26	T12 - L1	17.33	1.006	5.138
27	L1 - L2	15.93	2.412	2.674
28	L2 - L3	23.24	2.400	4.280
29	L3 - L4	18.52	.9755	2.543
30	L4 - L5	16.38	1.770	6.223
31	L5 - S1	16.58	3.986	8.015
42	L5 - S1	10.86	1.714	3.028
44	L3 - L4	5.849	1.883	3.222
45	L2 - L3	15.00	2.910	5.435
47	T11 - T12	12.87	2.438	9.346
48	T12 - L1	11.25	1.524	1.895
49	T9 - T10	11.95	2.880	19.88
50	T10 - T11	7.026	1.958	4.710
51	T8 - T9	9.671	2.793	3.796
52	T7 - T8	20.84	2.448	6.532
53	T4 - T5	3.085	.4655	2.732
54	T6 - T7	6.415	.4647	2.935
56	T5 - T6	4.474	1.624	2.350
57	T2 - T3	24.41	2.362	2.267
59	T9 - T10	12.92	1.185	1.287
60	T4 - T5	14.09	3.745	3.137
61	T5 - T6	15.71	2.302	3.075
62	T6 - T7	15.55	1.771	4.843
63	T11 - T12	23.72	3.405	3.743
64	T7 - T8	14.49	3.933	3.447
65	T10 - T11	12.44	4.218	3.838
66	T8 - T9	14.69	2.837	2.656
68	T12 - L1	24.54	1.699	3.321

Table II

Young's modulus and the viscosity coefficient predicted by the two-parameter-solid model from Kazarian's datum on 47 human intervertebral joints. A comparison of the predicted strain values, $\epsilon(t_i)_{cal}$, of the Burns-Kaleps exact analysis scheme with the strain values obtained experimentally, $\epsilon(t_i)_{exp}$, by Kazarian is represented as an "average of the absolute % error" for each disc.

2-Parameter-Solid Model

Test I.D. No.	Spinal Segments	Area (sq cm)	Height (cm)	Young's Modulus ($x10^8$ g/cm-s^2)	Viscosity Coef. ($x10^{11}$ g/cm-s)	Average ABS(% Error)
1	T1 - T2	4.148	2.445	.9839	6.998	19.92
2	T2 - T3	5.619	2.515	1.314	.6806	5.735
4	T4 - T5	5.181	2.280	2.188	5.944	12.15
5	T5 - T6	5.568	2.085	1.132	4.486	11.99
6	T6 - T7	6.490	2.670	.5785	2.840	15.66
7	T7 - T8	7.632	2.755	1.080	2.232	11.81
8	T8 - T9	8.123	1.194	.5713	.1215	5.510
9	T9 - T10	7.781	2.240	1.044	7.015	15.52
10	T10 - T11	8.961	3.920	1.197	6.115	14.56
16	T2 - T3	5.787	2.431	.5518	2.096	19.28
17	T3 - T4	5.148	2.585	1.840	10.61	13.15
18	T4 - T5	5.310	2.445	.9504	4.754	15.80
19	T5 - T6	5.800	2.240	4.037	18.78	19.51
20	T6 - T7	6.123	2.340	1.881	6.215	18.87
21	T7 - T8	8.161	2.670	.4123	.9647	19.85
22	T8 - T9	8.032	2.615	.4930	2.208	18.89
23	T9 - T10	9.123	2.670	.6828	4.804	19.02
24	T10 - T11	10.329	2.795	.5257	2.985	20.82
25	T11 - T12	11.800	3.515	.6598	3.498	17.09
26	T12 - L1	11.181	3.725	.8273	3.617	17.33
27	L1 - L2	11.813	3.900	.8351	3.778	15.93
28	L2 - L3	14.219	3.535	.3185	2.117	23.24
29	L3 - L4	14.168	3.165	.5822	5.297	18.52
30	L4 - L5	17.219	3.160	.4841	2.195	16.38
31	L5 - S1	25.613	3.760	.1748	.6159	16.58
42	L5 - S1	19.213	4.350	.3960	1.158	10.86
44	L3 - L4	19.639	4.090	1.478	1.116	5.849
45	L2 - L3	18.523	2.635	.3239	1.266	15.00
47	T11 - T12	19.348	2.789	.4131	1.932	12.87
48	T12 - L1	24.181	2.340	.4953	1.136	11.25
49	T9 - T10	19.987	2.171	.2778	1.027	11.95
50	T10 - T11	18.256	2.180	.4156	2.700	7.026
51	T8 - T9	17.110	2.163	.4054	.7523	9.671
52	T7 - T8	16.213	2.645	.3927	2.645	20.84
53	T4 - T5	14.032	1.965	.9167	.2130	3.085
54	T6 - T7	11.858	2.600	.5589	.8911	6.415
56	T5 - T6	14.729	1.980	.4440	.2414	4.474
57	T2 - T3	9.929	2.160	.4317	.3973	24.41
59	T9 - T10	16.813	2.775	.2558	.6613	12.92
60	T4 - T5	11.142	2.240	.2596	1.306	14.09
61	T5 - T6	10.432	1.895	.3594	2.064	15.71
62	T6 - T7	12.329	1.850	.3356	1.422	15.55
63	T11 - T12	16.503	2.975	.3777	6.587	23.72
64	T7 - T8	13.690	2.660	1.035	3.519	14.49
65	T10 - T11	14.561	2.765	.5848	3.470	12.44
66	T8 - T9	16.329	2.705	.6893	1.905	14.69
68	T12 - L1	16.503	2.935	.3881	7.376	24.54

Table III

Young's moduli and the viscosity coefficient predicted by the three-parameter-solid model from Kazarian's datum on forty-seven human intervertebral joints. A comparison of the predicted strain values, $\epsilon(t_i)_{cal}$, of the Burns-Kaleps exact analysis scheme with the strain values obtained experimentally, $\epsilon(t_i)_{exp}$, by Kazarian is represented as an "average of the absolute percent error" for each of the 47 spinal segments.

3-Parameter-Solid Model

Test I.D. No.	Spinal Segments	Area (sq cm)	Height (cm)	Young's Moduli ($\times 10^8$ g/cm-s^2) E_1	E_2	Viscosity Coef. ($\times 10^{12}$ g/cm-s) η_1	Average ABS(% Error)
1	T1 - T2	4.148	2.445	1.537	2.516	1.737	4.840
2	T2 - T3	5.619	2.515	3.494	2.041	.4972	.6767
4	T4 - T5	5.181	2.280	6.520	3.261	3.644	2.418
5	T5 - T6	5.568	2.085	2.006	2.515	1.312	.9041
6	T6 - T7	6.490	2.670	1.089	1.195	.9668	2.345
7	T7 - T8	7.632	2.755	1.847	2.375	.6643	1.913
8	T8 - T9	8.123	1.194	1.609	.6174	9.951	2.420
9	T9 - T10	7.781	2.240	1.574	2.156	2.931	2.009
10	T10 - T11	8.961	3.920	1.684	2.406	2.728	1.603
16	T2 - T3	5.787	2.431	1.709	.7219	2.701	11.35
17	T3 - T4	5.148	2.585	2.425	4.729	3.171	1.265
18	T4 - T5	5.310	2.445	1.589	1.991	1.661	1.721
19	T5 - T6	5.800	2.240	15.61	4.933	20.98	1.830
20	T6 - T7	6.123	2.340	6.213	2.462	8.357	1.452
21	T7 - T8	8.161	2.670	1.528	.5934	.5397	2.457
22	T8 - T9	8.032	2.615	.9229	.9479	.8675	1.604
23	T9 - T10	9.123	2.670	.9761	1.732	1.337	1.805
24	T10 - T11	10.329	2.795	1.089	1.002	1.068	1.647
25	T11 - T12	11.800	3.515	1.347	.9843	3.436	1.383
26	T12 - L1	11.181	3.725	2.304	1.132	3.248	1.006
27	L1 - L2	11.813	3.900	1.992	1.261	2.964	2.412
28	L2 - L3	14.219	3.535	.5875	.5786	1.028	2.400
29	L3 - L4	14.168	3.165	.8527	1.359	1.606	.9755
30	L4 - L5	17.219	3.160	.9414	.8826	.9423	1.770
31	L5 - S1	25.613	3.760	.4162	.2935	.2475	3.986

3-Parameter-Solid Model

Test I.D. No.	Spinal Segments	Area (sq cm)	Height (cm)	Young's Moduli ($x10^8$ g/cm-s^2) E_1	E_2	Viscosity Coef. ($x10^{12}$ g/cm-s) 1	Average ABS(% Error)
42	L5 - S1	19.213	4.350	.8581	.6434	.5912	1.714
44	L3 - L4	19.639	4.090	20.73	1.623	7.291	1.883
45	L2 - L3	18.523	2.635	.001476	.4073	2.988	2.910
47	T11 - T12	19.348	2.789	.7506	.9850	.4332	2.438
48	T12 - L1	24.181	2.340	2.468	.5968	2.016	1.524
49	T9 - T10	19.987	2.171	.5375	.5850	.2535	2.880
50	T10 - T11	18.256	2.180	.4967	2.519	.3836	1.958
51	T8 - T9	17.110	2.163	.7211	.8103	.2403	2.793
52	T7 - T8	16.213	2.645	.6098	1.282	.2995	2.448
53	T4 - T5	14.032	1.965	6.312	1.037	1.262	.4655
54	T6 - T7	11.858	2.600	1.333	.9210	.4274	.4647
56	T5 - T6	14.729	1.980	1.212	.6726	.1634	1.624
57	T2 - T3	9.929	2.160	.7696	1.138	.6707	2.362
59	T9 - T10	16.813	2.775	.6256	.3378	1.067	1.185
60	T4 - T5	11.142	2.240	.5680	.4761	.4915	3.745
61	T5 - T6	10.432	1.895	.5837	.8969	.5810	2.466
62	T6 - T7	12.329	1.850	.5383	.7909	.4042	1.771
63	T11 - T12	16.503	2.975	.7111	.8390	1.805	3.405
64	T7 - T8	13.690	2.660	3.126	1.343	4.711	3.933
65	T10 - T11	14.561	2.765	.6621	1.126	1.961	4.218
66	T8 - T9	16.329	2.705	11.10	.7764	7.435	2.837
68	T12 - L1	16.503	2.935	.6645	1.076	1.767	1.699

Table IV

Young's moduli and the viscosity coefficients predicted by the four-parameter-solid model from Kazarian's datum on forty-seven human intervertebral joints. A comparison of the predicted strain values, $\epsilon(t_i)_{cal}$, of the Burns-Haleps exact analysis scheme with the experimental strain values, $\epsilon(t_i)_{exp}$, obtained by Kazarian is represented as an "average of the absolute percent error" for each of the forty-seven spinal segments.

4-Parameter-Solid Model

Test I.D. No.	Spinal Segments	Area (sq cm)	Height (cm)	Young's Moduli ($\times 10^8$ g/cm-s^2) E_1	E_2	Viscosity Coef. ($\times 10^{11}$ g/cm-s) η_1	η_2	Average ABS(% Error)
1	T1 - T2	4.148	2.445	2.558	1.530	.6985	16.95	4.440
2	T2 - T3	5.619	2.515	5.736	1.705	10.74	.3868	3.572
4	T4 - T5	5.181	2.280	3.430	6.289	.9441	25.86	3.980
5	T5 - T6	5.568	2.085	2.114	2.392	14.52	.1575	1.473
6	T6 - T7	6.490	2.670	1.172	1.134	10.60	.2066	4.194
7	T7 - T8	7.632	2.755	2.052	2.165	7.847	.2524	2.372
8	T8 - T9	8.123	1.194	6.630	.5956	124.9	.4400	10.51
9	T9 - T10	7.781	2.240	2.091	1.518	1.131	32.68	6.044
10	T10 - T11	8.961	3.920	1.831	2.497	24.85	.8423	4.405
16	T2 - T3	5.787	2.431	.9584	1.222	.4252	9.279	6.953
17	T3 - T4	5.148	2.585	2.772	4.482	32.75	3.883	6.218
18	T4 - T5	5.310	2.445	1.909	1.523	.3870	18.65	3.029
19	T5 - T6	5.800	2.240	5.254	12.95	1.615	163.1	5.649
20	T6 - T7	6.123	2.340	2.673	6.724	.1584	37.91	3.148
21	T7 - T8	8.161	2.670	.5474	1.752	.09549	9.706	4.834
22	T8 - T9	8.032	2.615	.8481	.8358	.1262	13.66	2.634
23	T9 - T10	9.123	2.670	1.609	.9772	.3226	15.00	3.136
24	T10 - T11	10.329	2.795	.9136	1.260	.1495	13.51	2.527
25	T11 - T12	11.800	3.515	.9414	1.709	.2547	33.37	3.518
26	T12 - L1	11.181	3.725	1.097	2.537	.3273	34.32	5.138
27	L1 - L2	11.813	3.900	1.240	2.436	.1467	26.92	2.674
28	L2 - L3	14.219	3.535	.6255	.5622	10.41	.1194	4.280
29	L3 - L4	14.168	3.165	1.301	.7765	.3745	18.38	2.543
30	L4 - L5	17.219	3.160	.8185	.7433	.4024	14.36	6.223
31	L5 - S1	25.613	3.760	.2354	.4411	.1848	7.761	8.015

4-Parameter-Solid Model

Test Exp. No.	Spinal Segments	Area (sq cm)	Height (cm)	Young's Moduli ($\times 10^8$ g/cm-s^2) E_1	E_2	Viscosity Coef. ($\times 10^{11}$ g/cm-s) η_1	η_2	Average ABS(% Error)
42	T5 - T6	19.213	4.350	.5533	1.109	.2977	10.50	3.028
44	T3 - T4	19.639	4.090	9.795	1.585	201.6	.4873	3.222
45	T1 - T2	16.589	4.035	.1158	.4131	27.24	.2856	5.435
47	T11 - T12	19.348	2.789	1.071	.5904	1.412	5.202	9.346
48	T12 - L1	24.181	2.340	.5883	1.692	.1107	27.77	1.895
49	T9 - T10	19.987	2.171	.6339	.5035	3.522	2.319	19.88
50	T10 - T11	18.256	2.180	2.530	.4843	4.562	3.836	4.710
51	T8 - T9	17.110	2.163	.6925	.6709	.03540	3.775	3.796
52	T7 - T8	16.213	2.645	.6118	.7744	.9187	14.86	6.532
53	T4 - T5	14.032	1.965	22.13	.9653	34.31	.05332	2.732
54	T6 - T7	11.858	2.600	1.454	.9422	3.630	.08159	2.935
56	T5 - T6	14.729	1.980	1.356	.6109	2.812	.06332	2.350
57	T2 - T3	9.929	2.160	1.065	.7299	.1457	8.153	2.267
59	T9 - T10	16.813	2.775	.3280	.6477	.07844	12.64	1.287
60	T4 - T5	11.142	2.240	.4424	.5541	.1525	6.862	3.137
61	T5 - T6	10.432	1.895	.8086	.5288	.2247	7.303	3.075
62	T6 - T7	12.329	1.850	.5694	.7587	4.124	.2068	4.843
63	T11 - T12	16.503	2.975	.7793	.7690	.5481	20.69	3.743
64	T7 - T8	13.690	2.660	1.559	2.970	.2139	12.93	3.447
65	T10 - T11	14.561	2.765	.9871	.5945	.3767	24.58	3.838
66	T8 - T9	16.329	2.705	13.35	.7622	44.69	.02962	2.656
68	T12 - L1	16.503	2.935	.6523	1.021	19.40	.3047	3.321

Table V

Identification of Dr. Leon E. Kazarian's rhesus monkey datum for fifty-nine intervertebral joints.

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DTIC-DDA 2
13 Nov 81

Table VI

Mechanical properties and error results (as defined on p. 8) predicted by the two-parameter-solid model analysis of Dr. Leon E. Kazarian's datum on fifty-nine rhesus monkey spinal segments.

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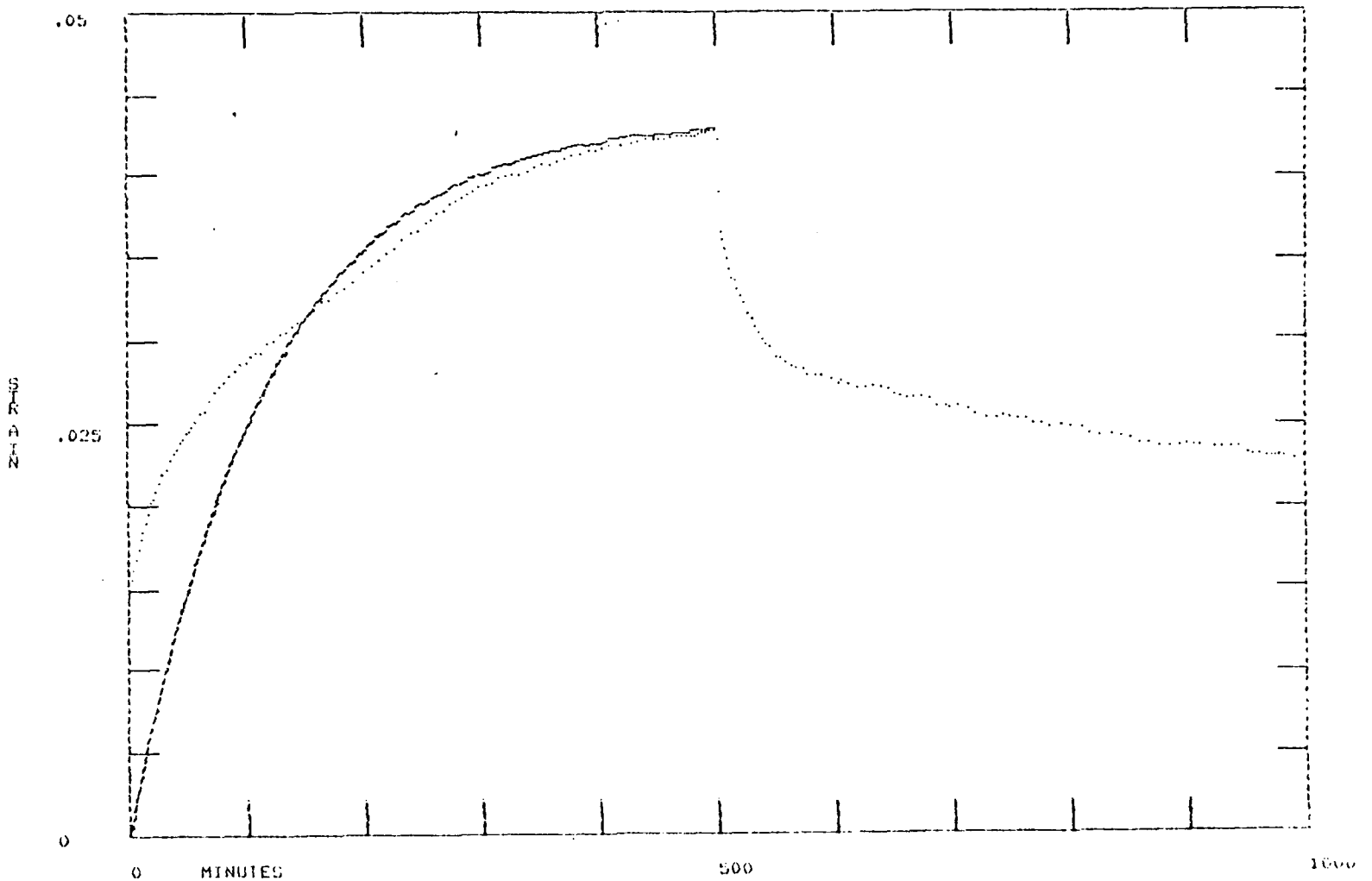
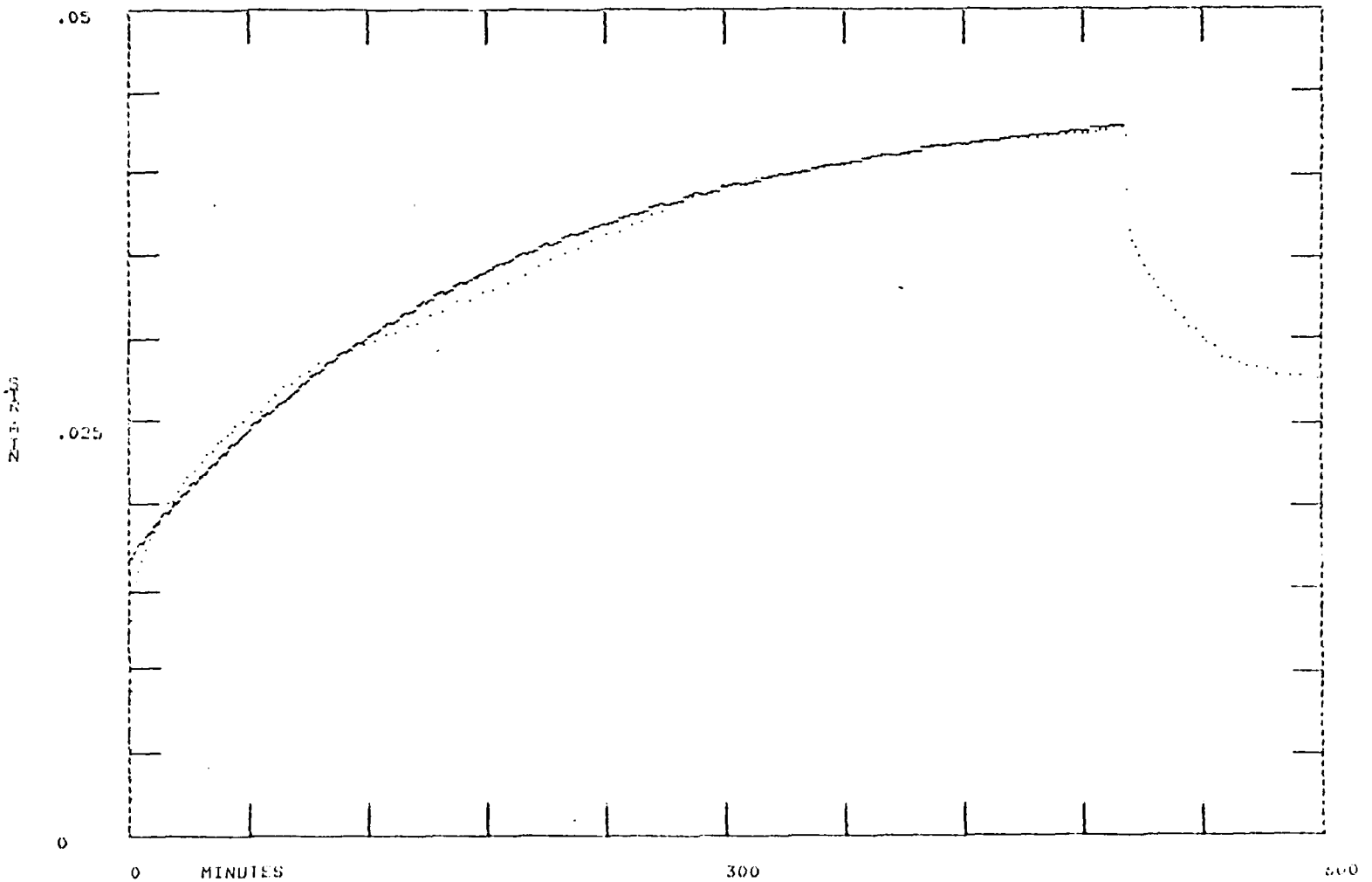
13 Nov 81



2-PARAMETER SOLID MODEL WITH VALUES OF
A1 = .043574, B1 = 8.4356E-03, A2 = 0
DELTA TIME = 30
ERROR (USING ALL POINTS): 2.836%
ERROR (IGNORING FIRST 3 POINTS): 2.257%

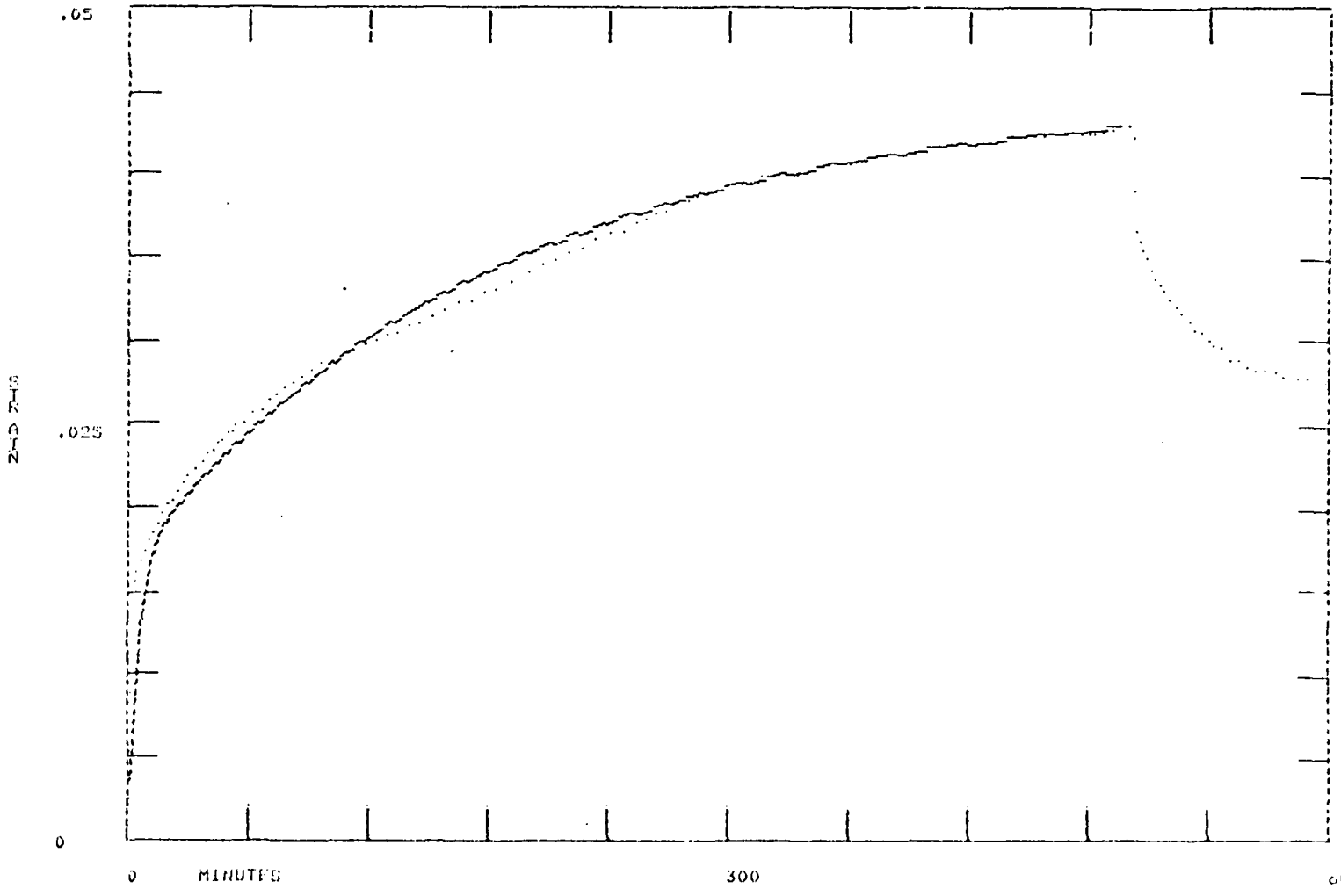
LK-01 T1-T2 19 MAY 75 AREA = 4.15 SQ CM HEIGHT = 2.445 CM
DOTTED LINE: ORIGINAL DATA HEAVY LINE: MODEL PREDICTION

1



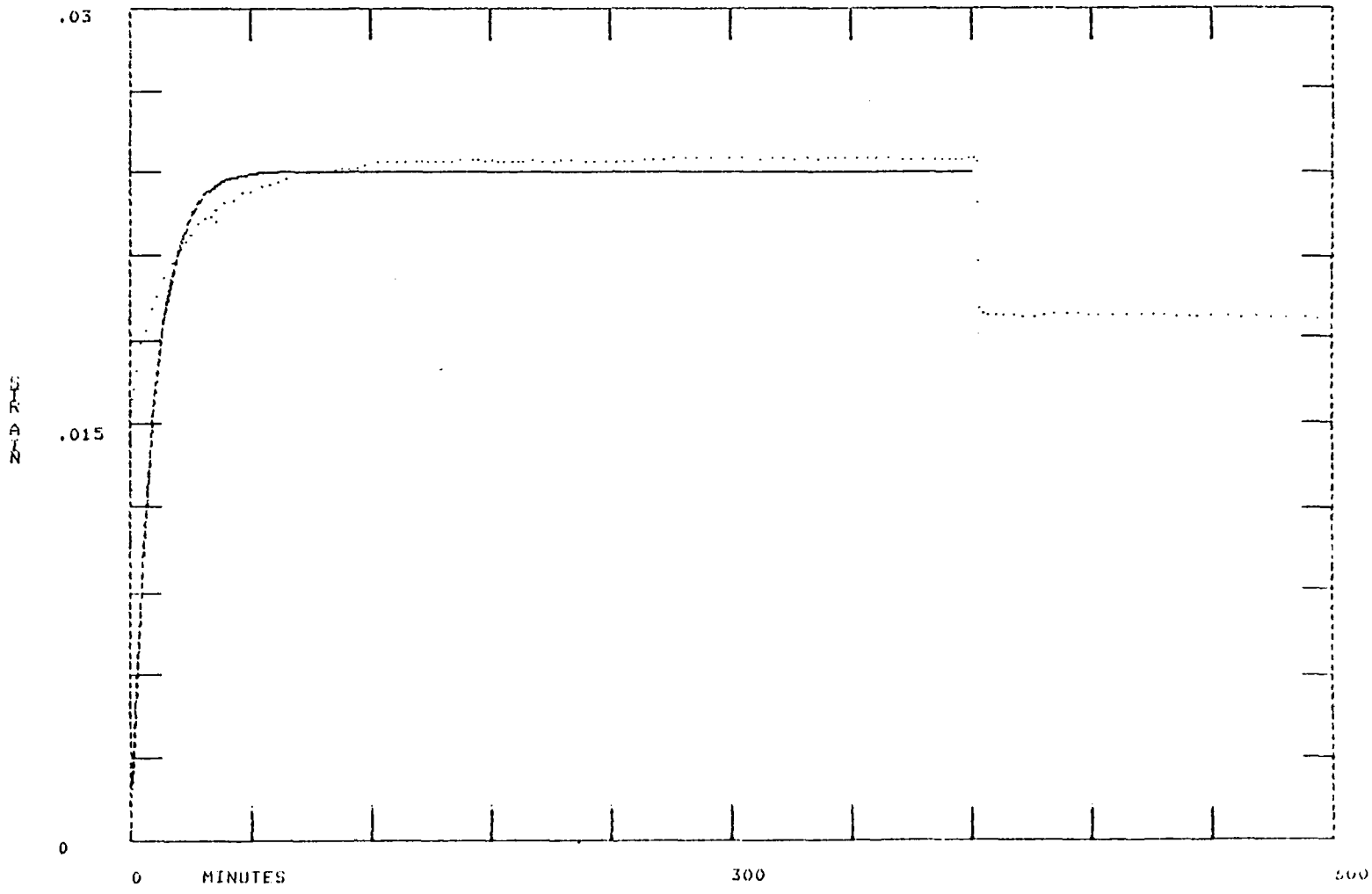
3-PARAMETER SOLID MODEL WITH VALUES OF
A1 = .044239, B1 = 5.3068E-03, A2 = .017039
DELTA TIME = 4
ERROR (USING ALL POINTS): -2.043%
ERROR (IGNORING FIRST 3 POINTS): -1.184%

LX-01 TI-12 19 MAY 75 AREA = 4.15 SQ CM HEIGHT = 2.445 CM
DOTTED LINE: ORIGINAL DATA HEAVY LINE: MODEL PREDICTION



4-PARAMETER SOLID MODEL WITH VALUES OF
A1 = .016766, B1 = .21977, A2 = .028039, B2 = 5.4144E-03
DELTA TIME = 4
ERROR (USING ALL POINTS): 1.140%
ERROR (IGNORING FIRST 3 POINTS): 1.143%

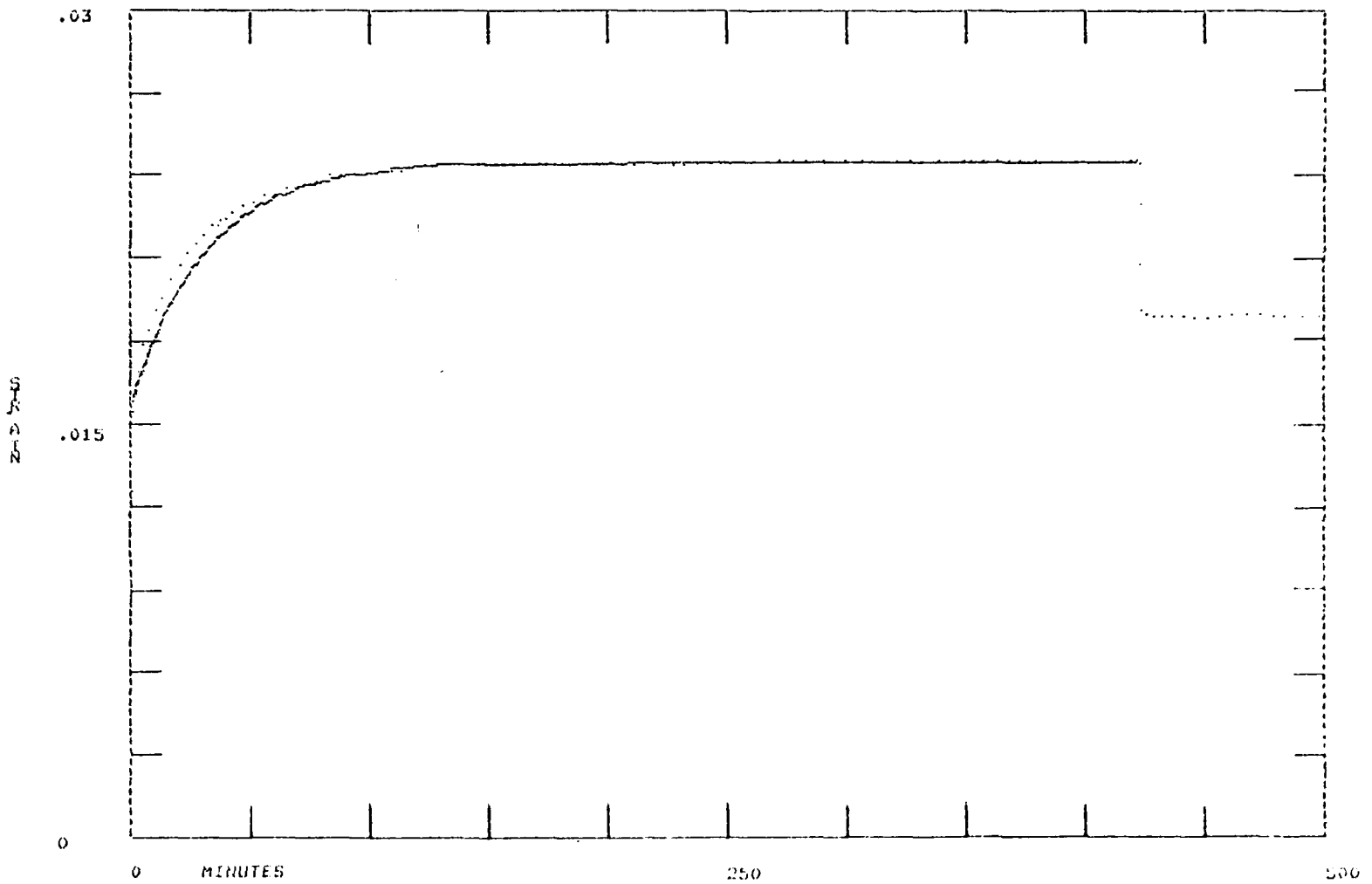
LN-01 T1-T2 19 MAY 75 AREA = 4.15 SQ CM HEIGHT = 2.445 CM
DOTTED LINE: ORIGINAL DATA HEAVY LINE: MODEL PREDICTION



2-PARAMETER SOLID MODEL WITH VALUES OF
A1 = .0224093, B1 = .0895226, A2 = 0

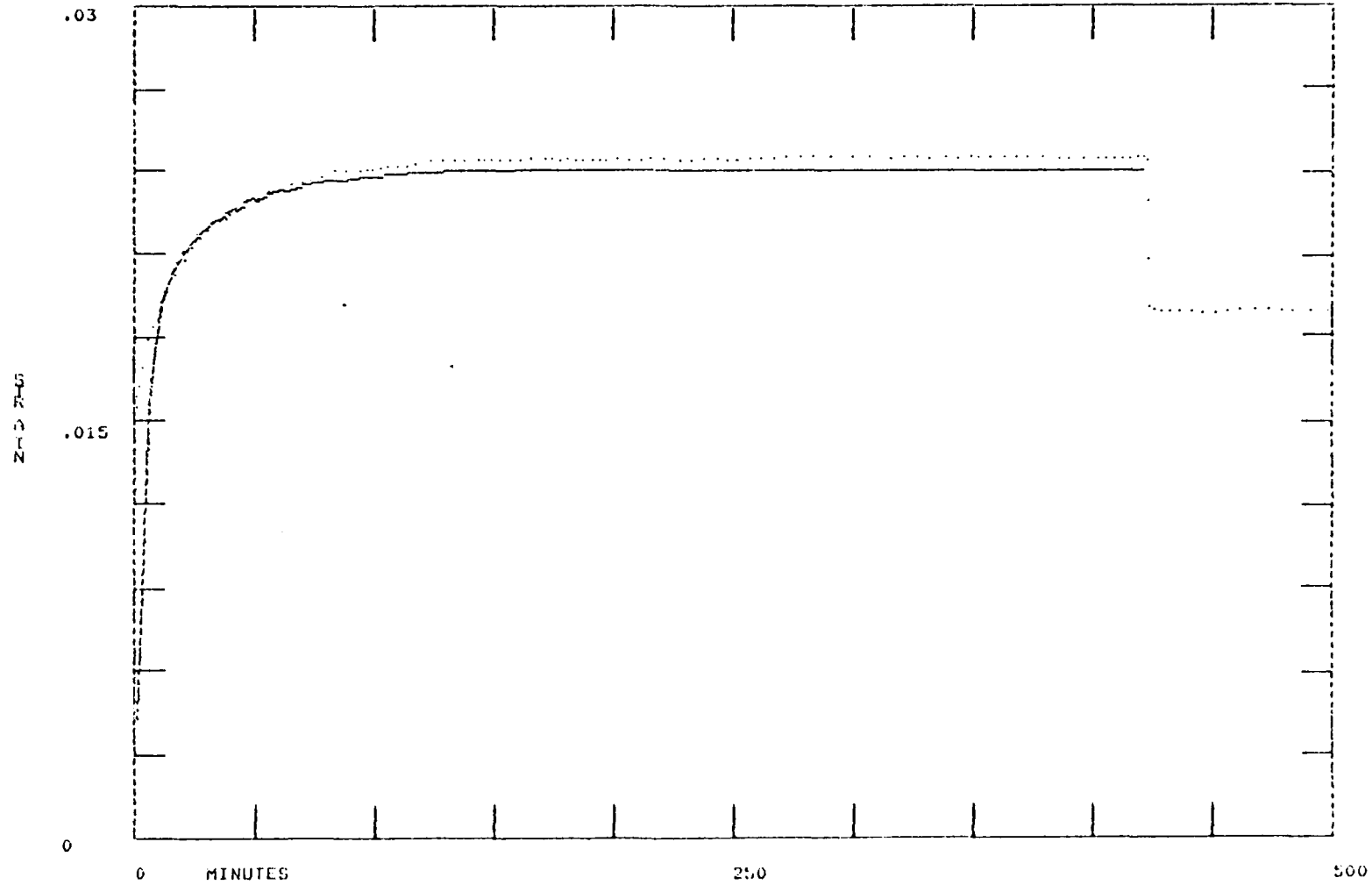
DELTA TIME = 0
ERROR (USING ALL POINTS): 4.3522%
ERROR (IGNORING FIRST 3 POINTS): 3.5992%

LK-02 T2-T3 21 MAY 75 AREA = 5.62 SQ CM HEIGHT = 2.515 CM
DOTTED LINE: ORIGINAL DATA HEAVY LINE: MODEL PREDICTION



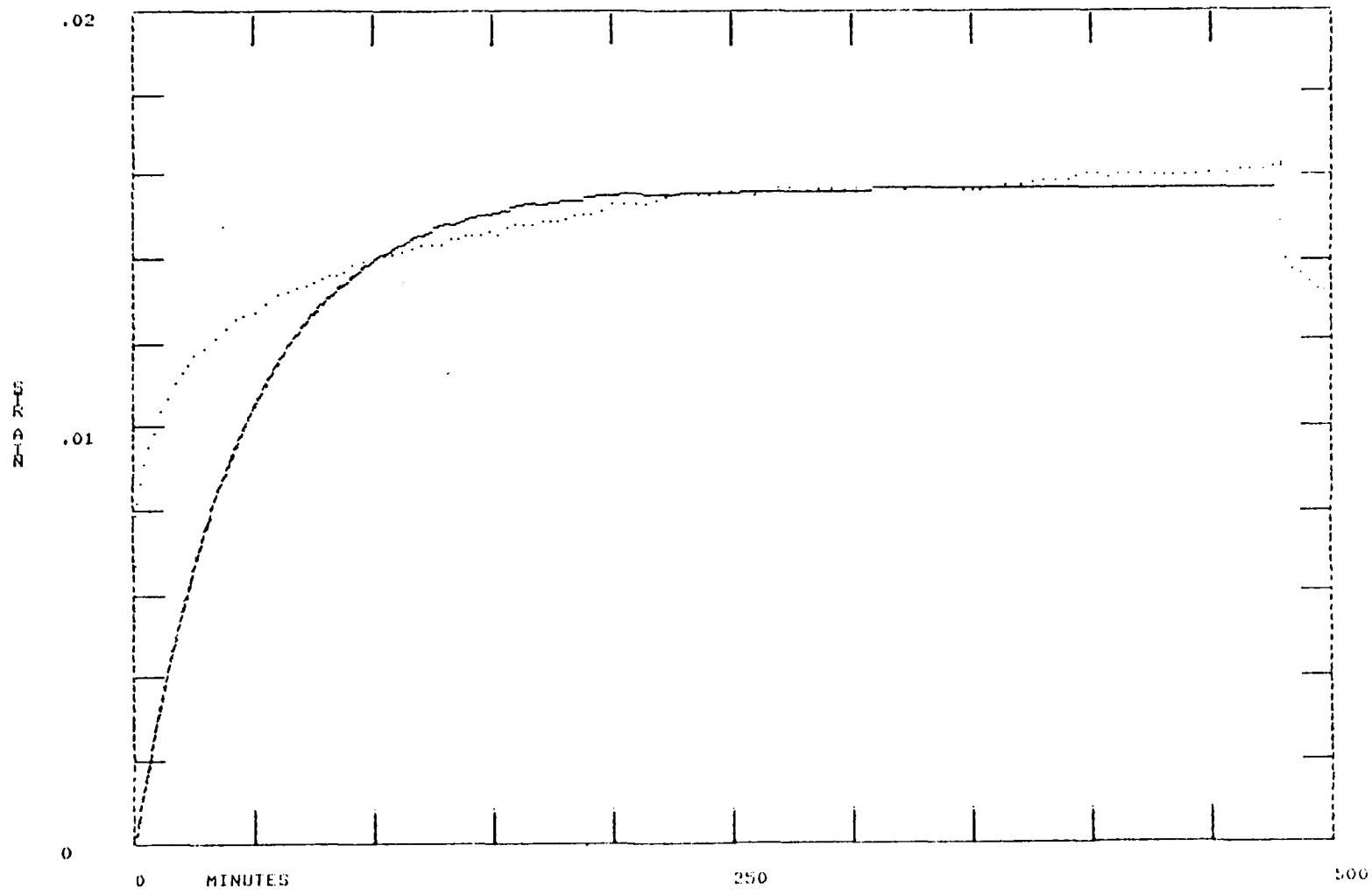
3-PARAMETER SOLID MODEL WITH VALUES OF
A1 = .022491, B1 = .032222, A2 = .015654
DELTA TIME = 16
ERROR (USING ALL POINTS): -0.153%
ERROR (IGNORING FIRST 3 POINTS): 0.440%

LN-02 T2-T3 21 MAY 75 AREA = 5.62 SQ CM HEIGHT = 2.515 CM
DOTTED LINE: ORIGINAL DATA HEAVY LINE: MODEL PREDICTION



4-PARAMETER SOLID MODEL WITH VALUES OF
A1 = 5.5199E-03, B1 = .0320355, A2 = .0185726, B2 = .226439
DELTA TIME = 8
ERROR (USING ALL POINTS): 3.301%
ERROR (IGNORING FIRST 3 POINTS): 2.252%

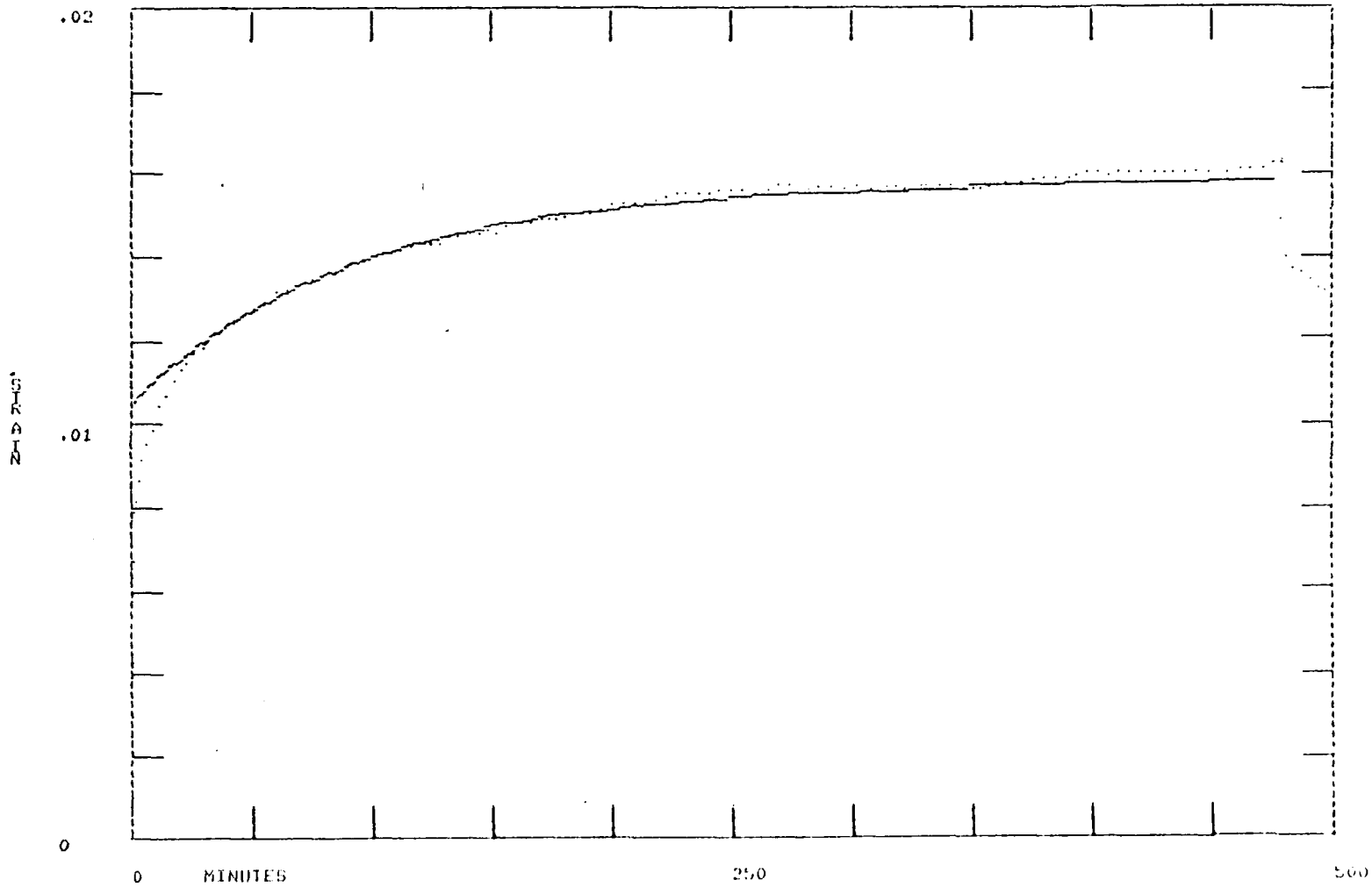
LK-02 T2-T3 21 MAY 75 AREA = 5.62 SQ CM HEIGHT = 2.515 CM
DOTTED LINE: ORIGINAL DATA HEAVY LINE: MODEL PREDICTION



2-PARAMETER SOLID MODEL WITH VALUES OF
A1 = .0156978, B1 = .0222087, A2 = 0

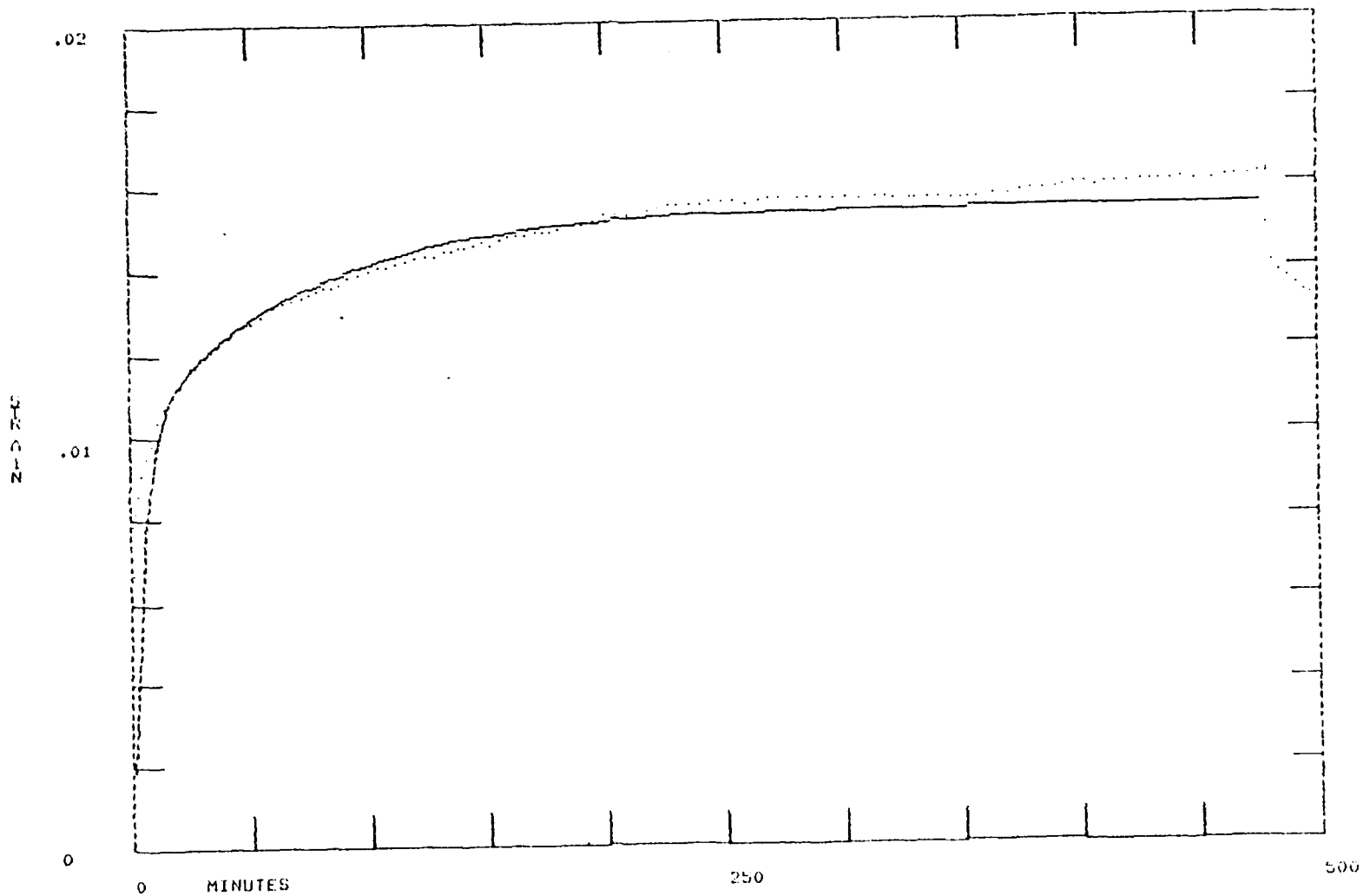
DELTA TIME = 8
ERROR (USING ALL POINTS): 6.8355%
ERROR (IGNORING FIRST 3 POINTS): 6.5000%

LK-04 T4-T5 04 SEP 75 AREA - 5.18 SQ CM HEIGHT - 2.28 CM
DOTTED LINE: ORIGINAL DATA HEAVY LINE: MODEL PREDICTION



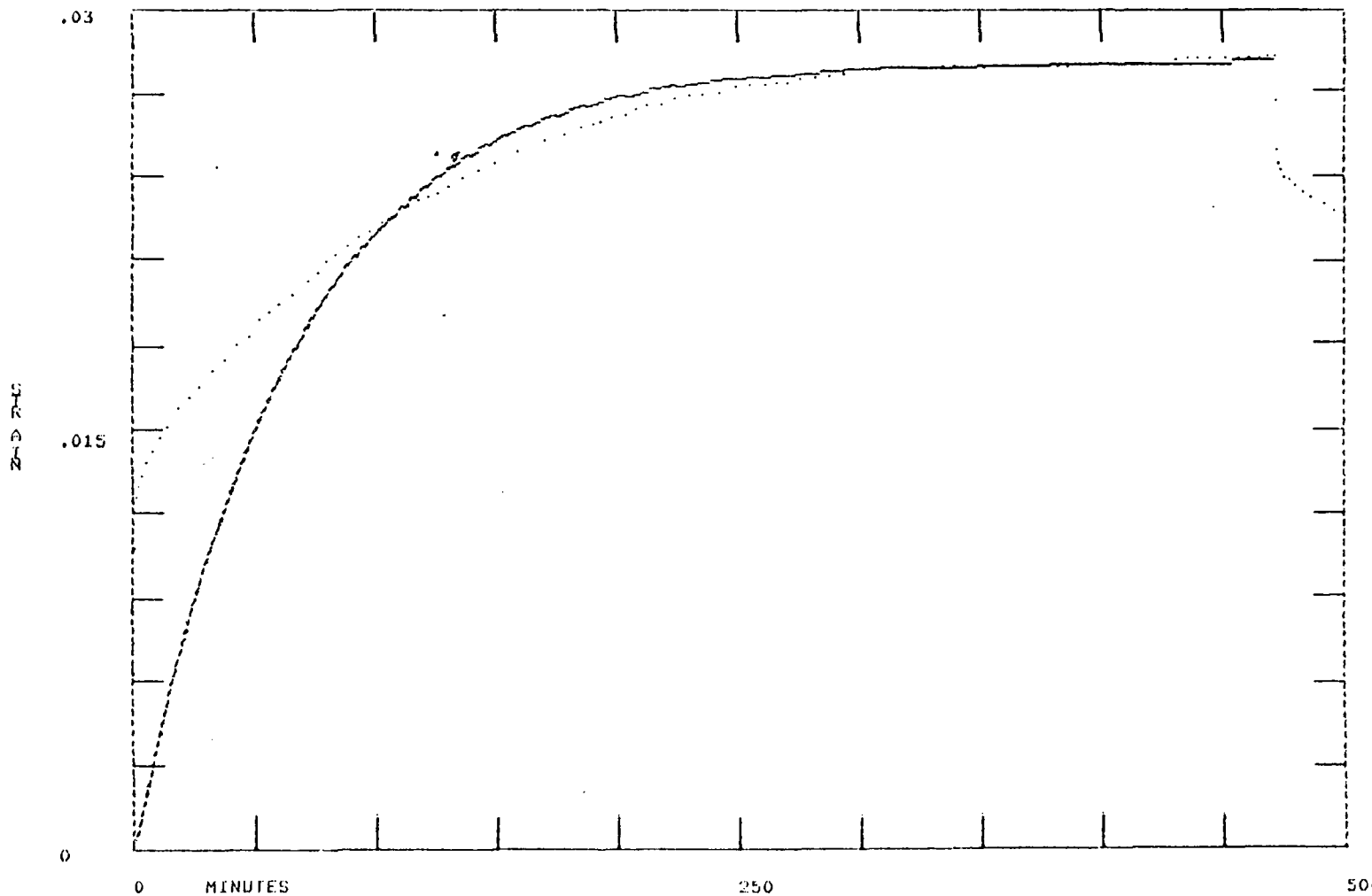
3-PARAMETER SOLID MODEL WITH VALUES OF
A1 = .015802, B1 = .010236, A2 = .010534
DELTA TIME = 4
ERROR (USING ALL POINTS): = 1.2659%
ERROR (IGNORING FIRST 3 POINTS): = 0.4224%

LK-04 T4-15 04 SEP 75 AREA = 5.18 SQ CM HEIGHT = 2.20 CM
DOTTED LINE: ORIGINAL DATA HEAVY LINE: MODEL PREDICTION



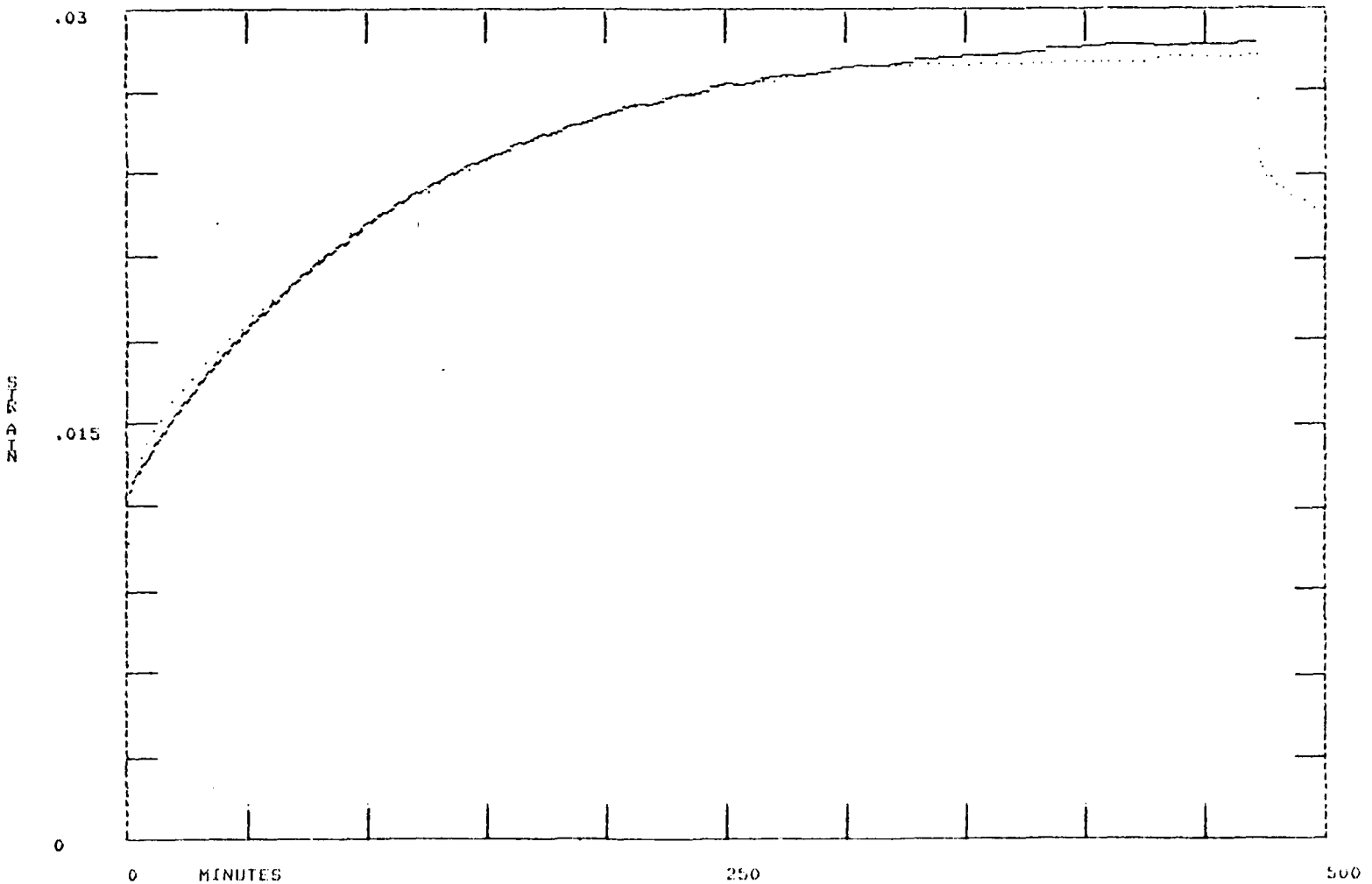
4-PARAMETER SOLID MODEL WITH VALUES OF
A1 = .010011, X1 = .218, A2 = 5.4608E-03, X2 = .014589
DELTA TIME = 8
ERROR (USING ALL POINTS): 2.585%
ERROR (IGNORING FIRST 3 POINTS): 2.333%

IK-04 T4-T5 04 SEP 75 AREA = 5.18 SQ CM HEIGHT = 2.20 CM
DOTTED LINE: ORIGINAL DATA HEAVY LINE: MODEL PREDICTION



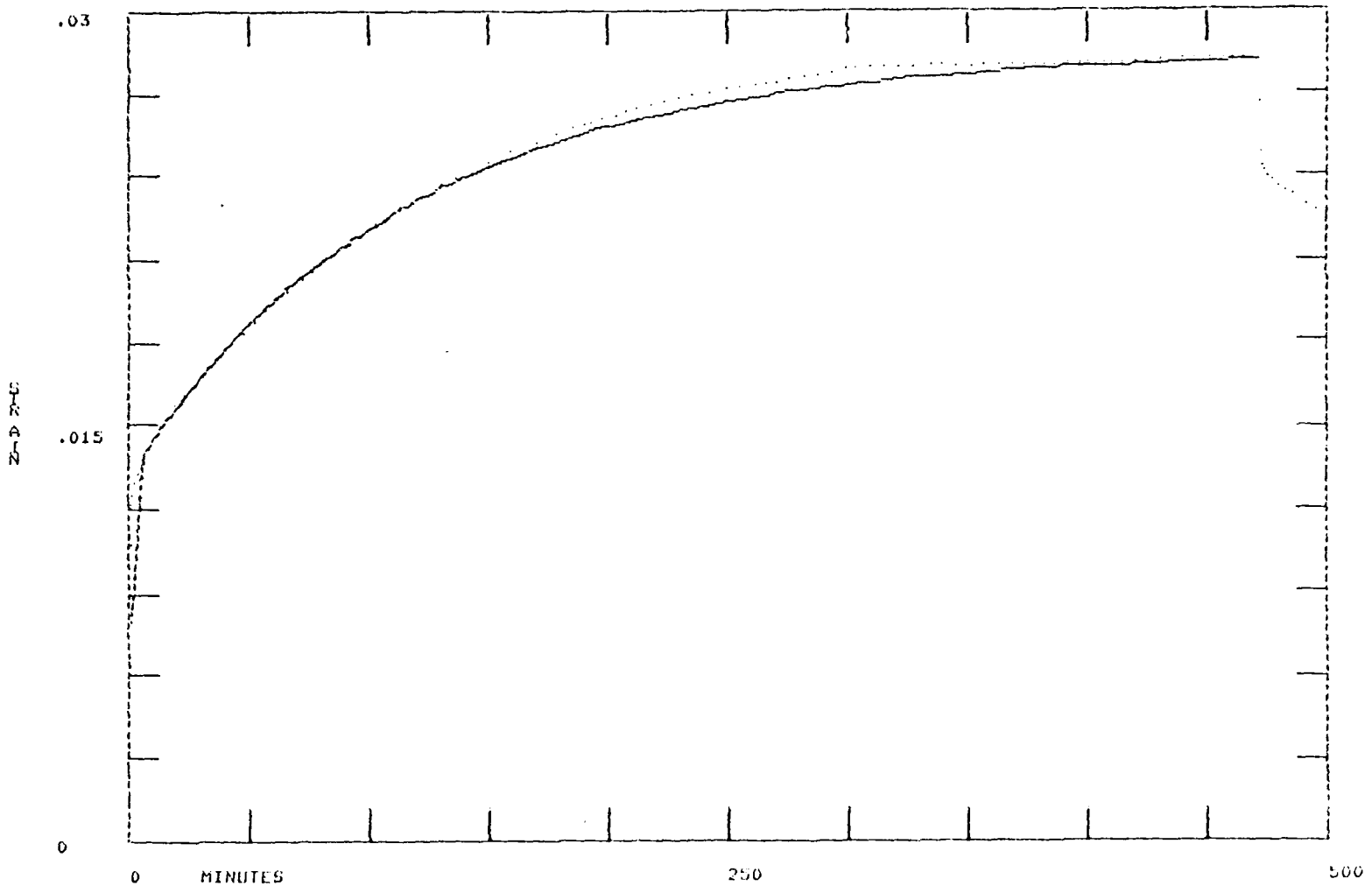
2-PARAMETER SOLID MODEL WITH VALUES OF
A1 = .0228229, B1 = .0151133, A2 = 0
DELTA TIME = 16
ERROR (USING ALL POINTS): 6.419%
ERROR (IGNORING FIRST 3 POINTS): 6.073%

LK-05 T5-T6 28 AUG 75 AREA = 5.57 50 CM HEIGHT = 2.085 CM
DOTTED LINE: ORIGINAL DATA HEAVY LINE: MODEL PREDICTION



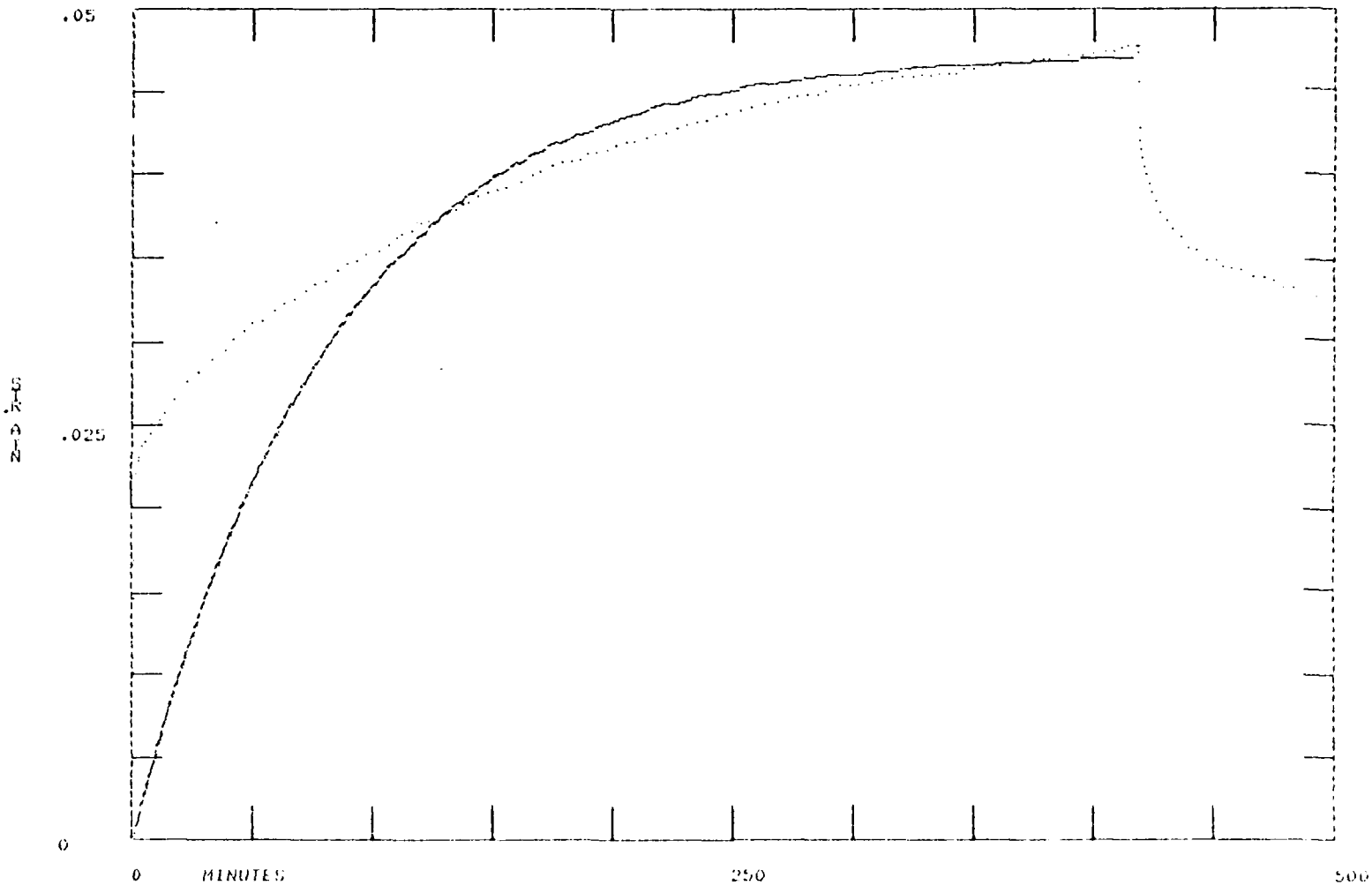
3-PARAMETER SOLID MODEL WITH VALUES OF
A1 = .0229165, B1 = 8.59035E-03, A2 = .0126352
DELTA TIME = 4
ERROR (USING ALL POINTS): -1.129%
ERROR (IGNORING FIRST 3 POINTS): -0.457%

LN-05 T5-T6 28 AUG 75 AREA = 5.57 SQ CM. HEIGHT = 2.085 CM
DOTTED LINE: ORIGINAL DATA HEAVY LINE: MODEL PREDICTION



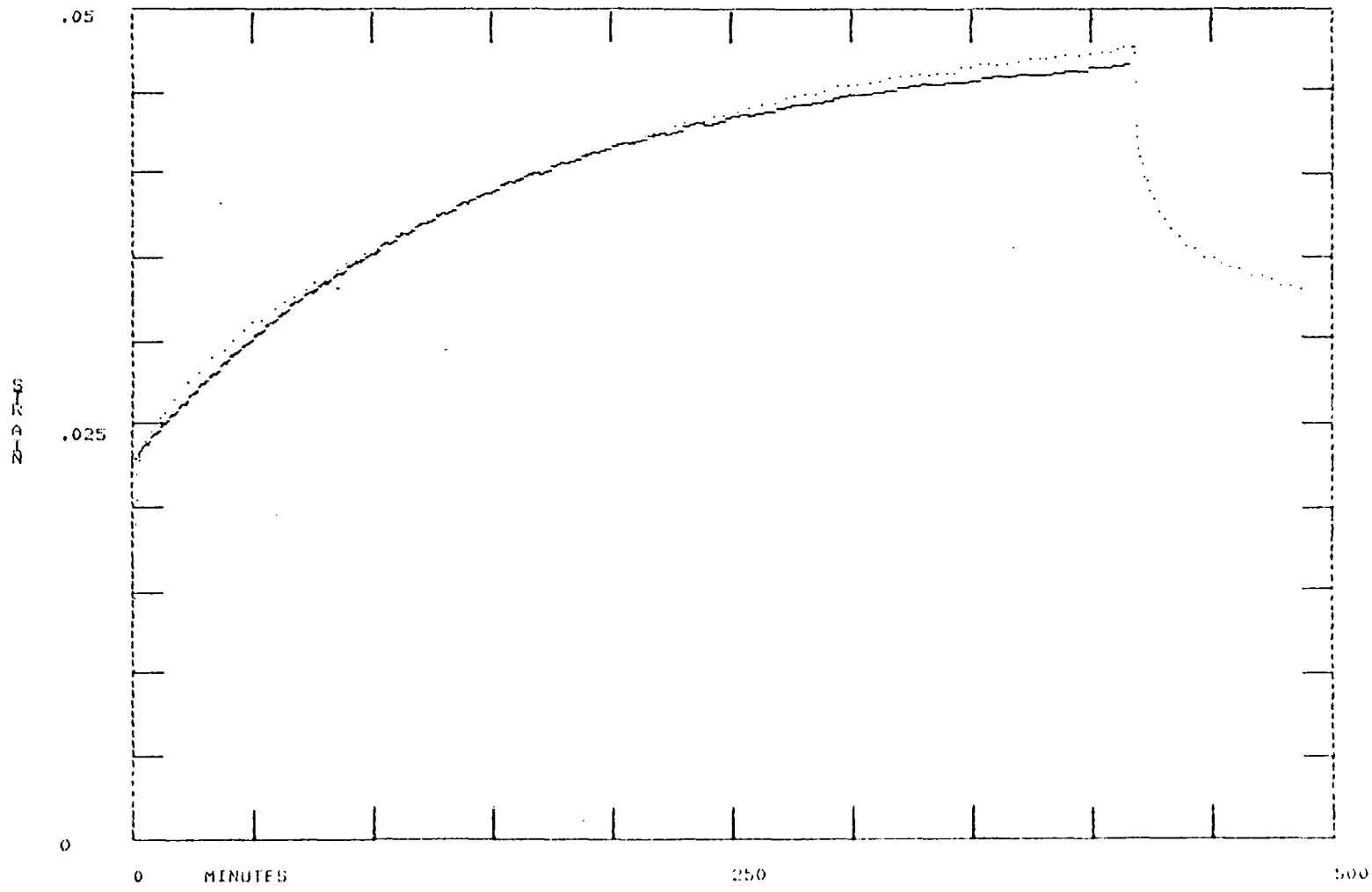
4-PARAMETER SOLID MODEL WITH VALUES OF
A1 = .015116, B1 = 8.7356E-03, A2 = .013361, B2 = .91083
DELTA TIME = 4
ERROR (USING ALL POINTS): 1.114%
ERROR (IGNORING FIRST 3 POINTS): 1.134%

LK-05 T5-T6 28 AUG 75 AREA = 5.57 SQ CM HEIGHT = 2.085 CM
DOTTED LINE: ORIGINAL DATA HEAVY LINE: MODEL PREDICTION



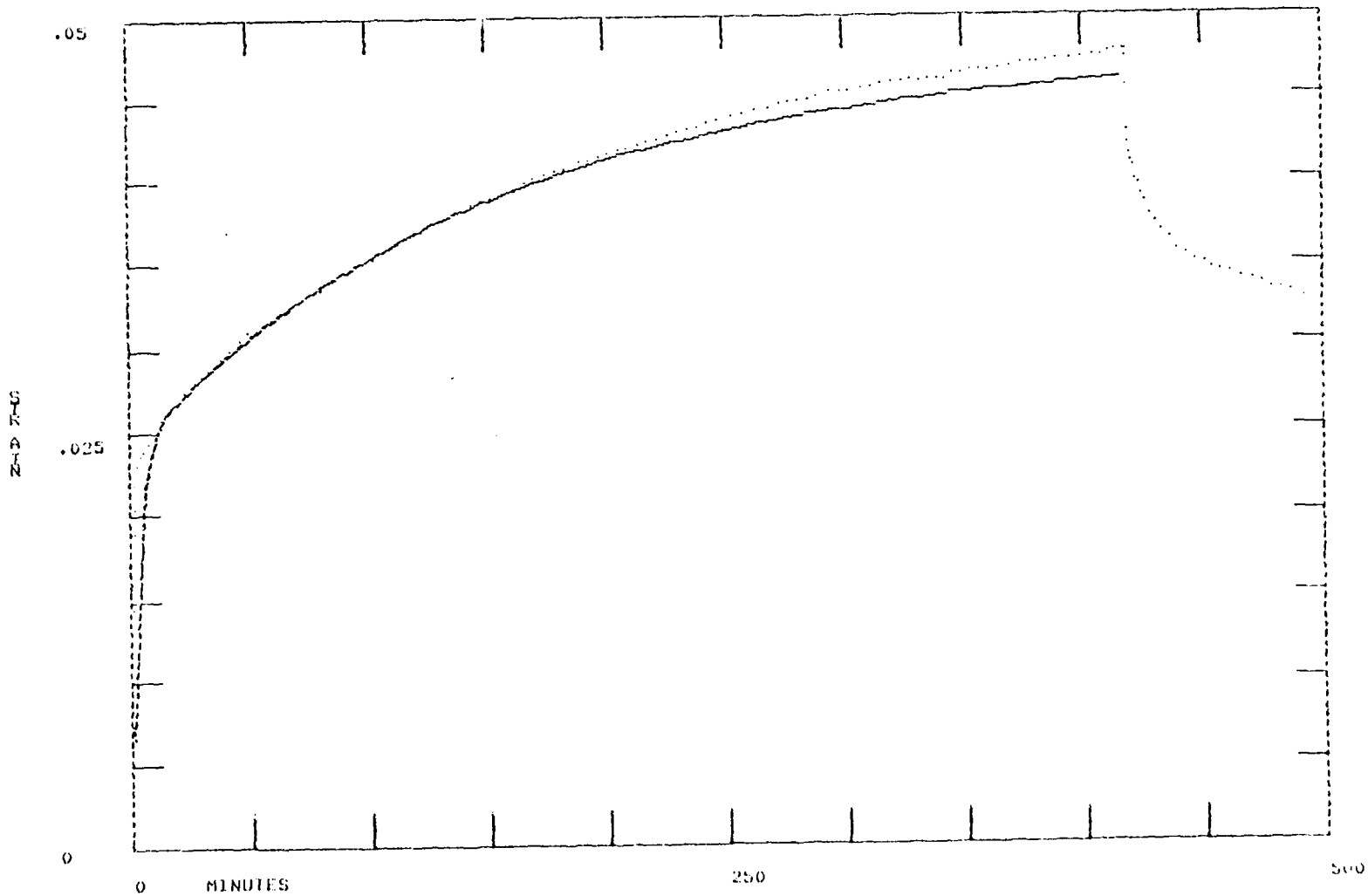
2-PARAMETER SOLID MODEL WITH VALUES OF
A1 = .0427589, B1 = .0122222, A2 = 0
DELTA TIME = 15
ERROR (USING ALL POINTS): 8.2627%
ERROR (IGNORING FIRST 3 POINTS): 7.9835%

LN-06 16:17 29 MAY 75 AREA - 6.49 SQ CM HEIGHT = 2.67 CM
DOTTED LINE: ORIGINAL DATA HEAVY LINE: MODEL PREDICTION



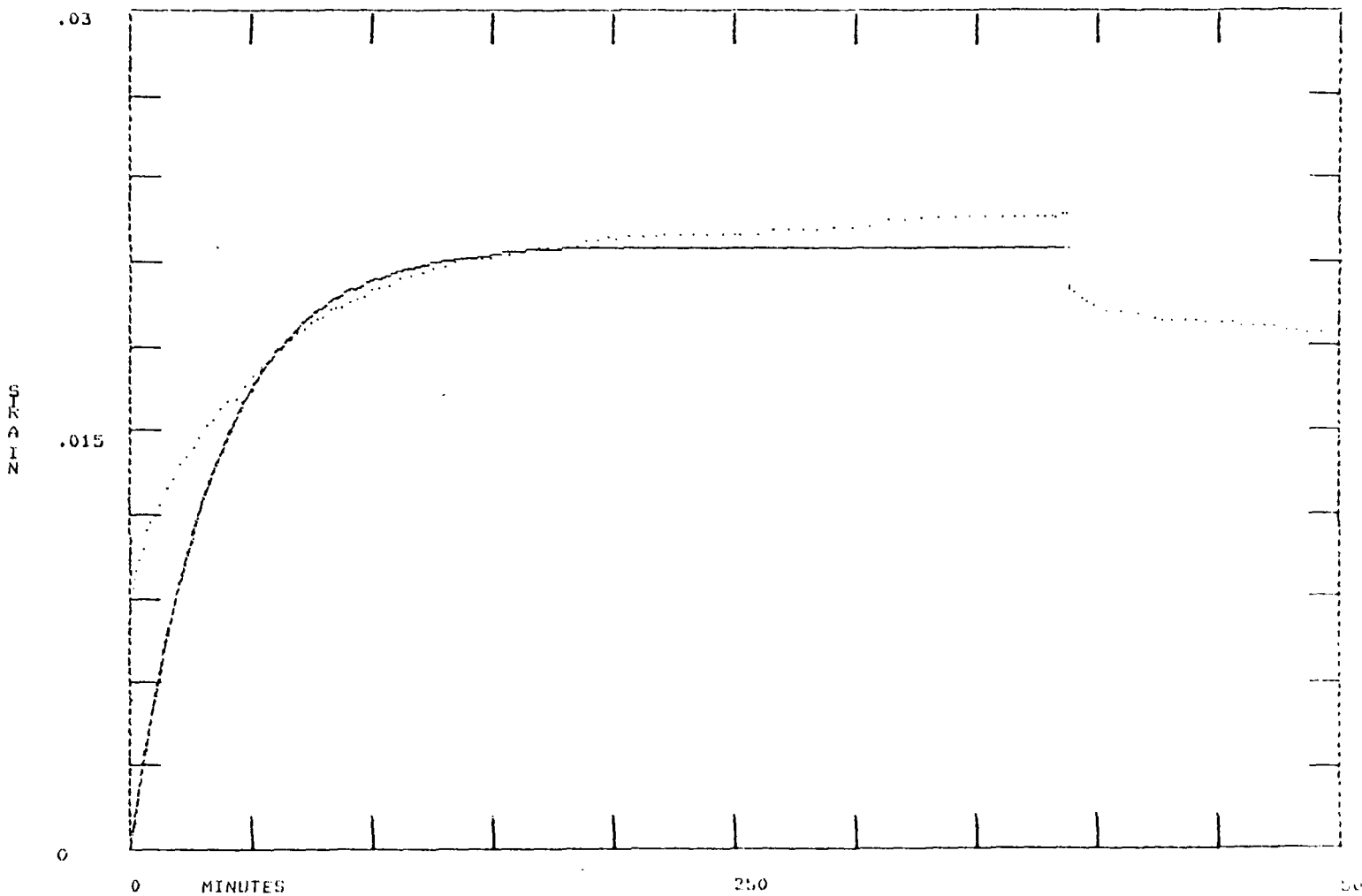
3-PARAMETER SOLID MODEL WITH VALUES OF
A1 = .048114, B1 = 6.7599E-03, A2 = .0223945
DELTA TIME = 4
ERROR (USING ALL POINTS): -0.072%
ERROR (IGNORING FIRST 3 POINTS): 0.65/%

LN-06 T6-T7 29 MAY 75 AREA = 6.49 SQ CM HEIGHT = 2.67 CM
DOTTED LINE: ORIGINAL DATA HEAVY LINE: MODEL PREDICTION



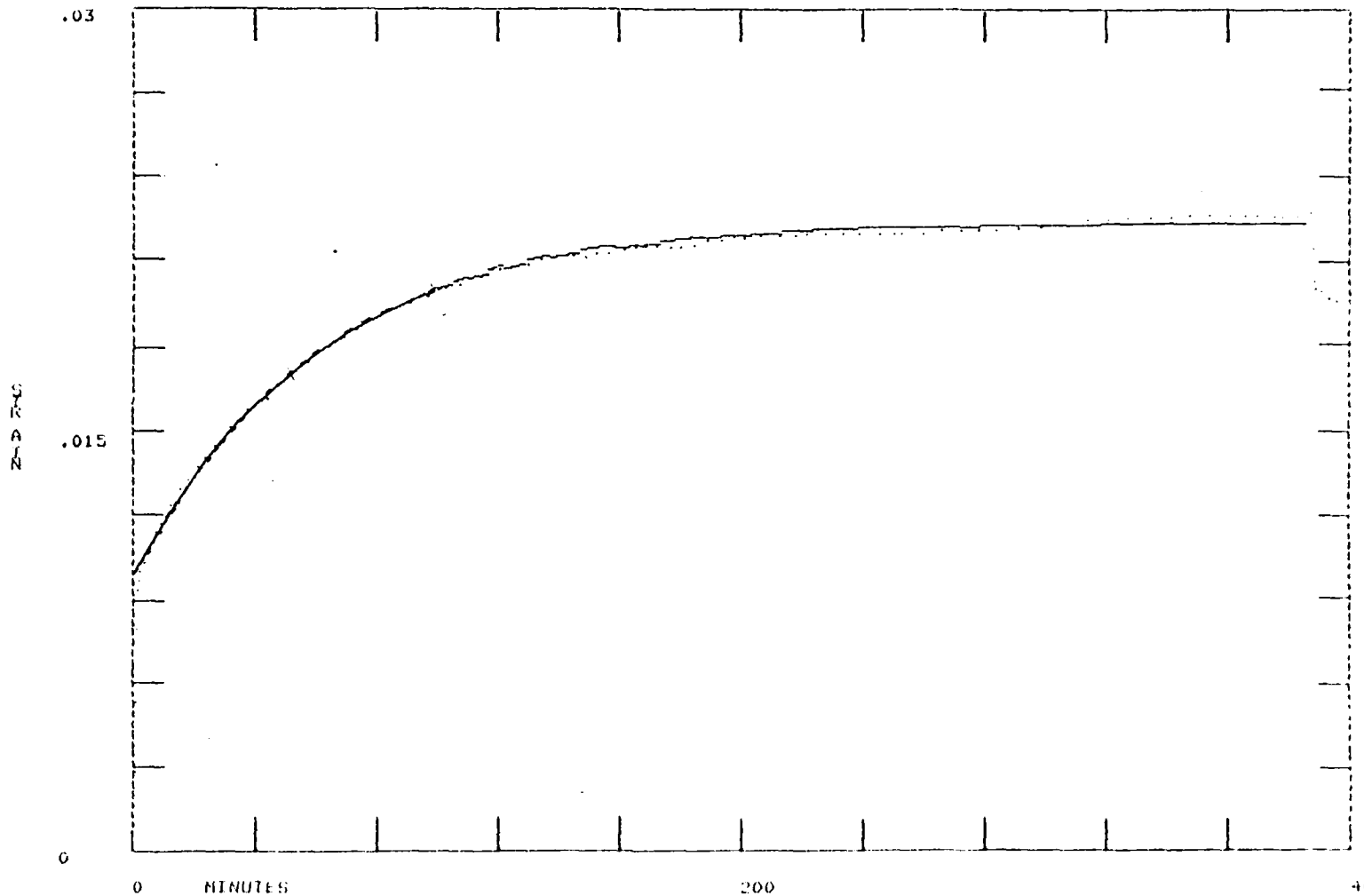
4-PARAMETER SOLID MODEL WITH VALUES OF
A1 = .0223588, E1 = 6.6349E-03, A2 = .0241729, E2 = .3229222
DELTA TIME = 8
ERROR (USING ALL POINTS): 3.083%
ERROR (CONSIDERING FIRST 3 POINTS): 2.935%

LN-06 To-T7 29 MAY 75 AREA = 6.49 50 CM HEIGHT = 2.67 CM
DOTTED LINE: ORIGINAL DATA HEAVY LINE: MODEL PREDICTION



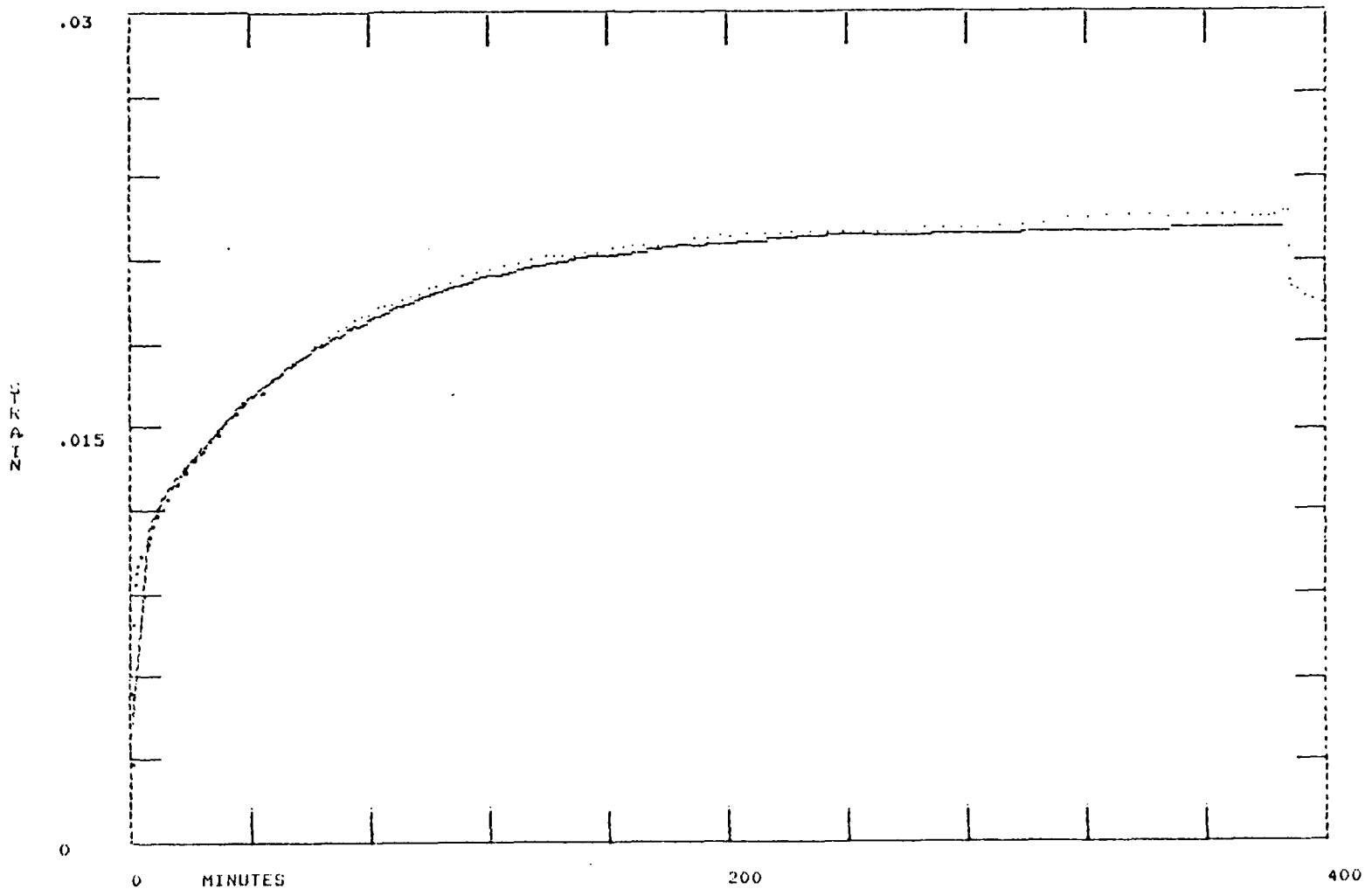
2-PARAMETER SOLID MODEL WITH VALUES OF
A1 = .022595, B1 = .029033, A2 = 0
DELTA TIME = 8
ERROR (USING ALL POINTS): 6.854%
ERROR (IGNORING FIRST 3 POINTS): 6.701%

LK-07 T7-T8 08 SEP 75 AREA = 7.63 SQ CM HEIGHT = 2.755 CM
DOTTED LINE: ORIGINAL DATA HEAVY LINE: MODEL PREDICTION



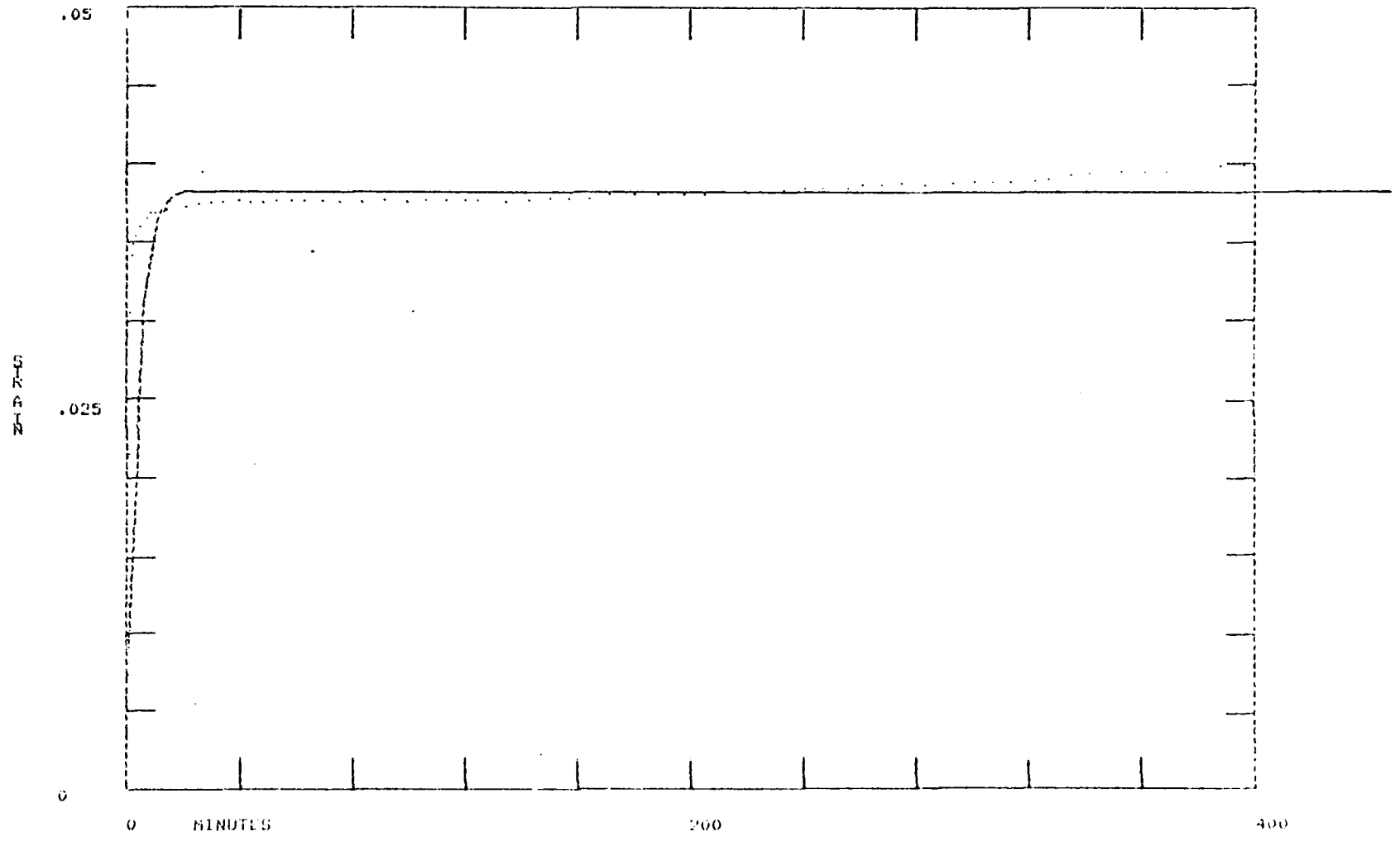
3-PARAMETER SOLID MODEL WITH VALUES OF
A1 = .0322442, B1 = .016687, A2 = 9.81992E-03
DELTA TIME = 4
ERROR (USING ALL POINTS): -1.302%
ERROR (IGNORING FIRST 3 POINTS): -0.485%

LN-07 T7-T8 08 SEP 75 AREA = 7.63 SQ CM HEIGHT = 2.755 CM
DOTTED LINE: ORIGINAL DATA HEAVY LINE: MODEL PREDICTION



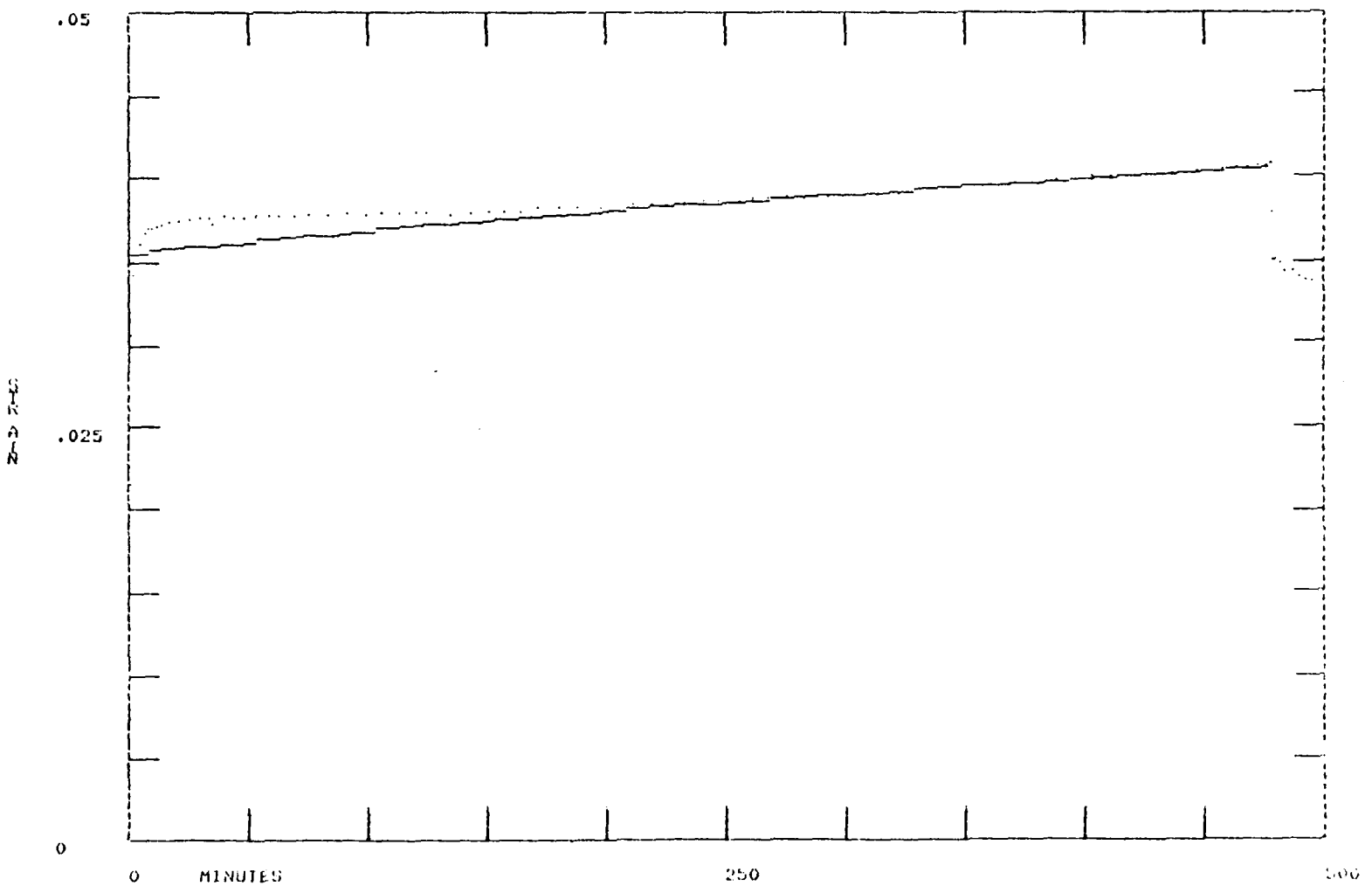
4-PARAMETER SOLID MODEL WITH VALUES OF
A1 = .011359, B1 = .015692, A2 = .01077, B2 = .51459
DELTA TIME = 8
ERROR (USING ALL POINTS): 1.442%
ERROR (IGNORING FIRST 3 POINTS): 1.503%

LK-07 17-18 08 SEP 75 AREA = 7.63 SQ CM HEIGHT = 2.755 CM
DOTTED LINE: ORIGINAL DATA HEAVY LINE: MODEL PREDICTION



2-PARAMETER SOLID MODEL WITH VALUES OF
A1 = .0388888 , A2 = .228222 , A3 = 0
DELTA TIME = 4
ERROR (USING ALL POINTS) : 3.5550%
ERROR (IGNORING FIRST 3 POINTS) : 3.0488%

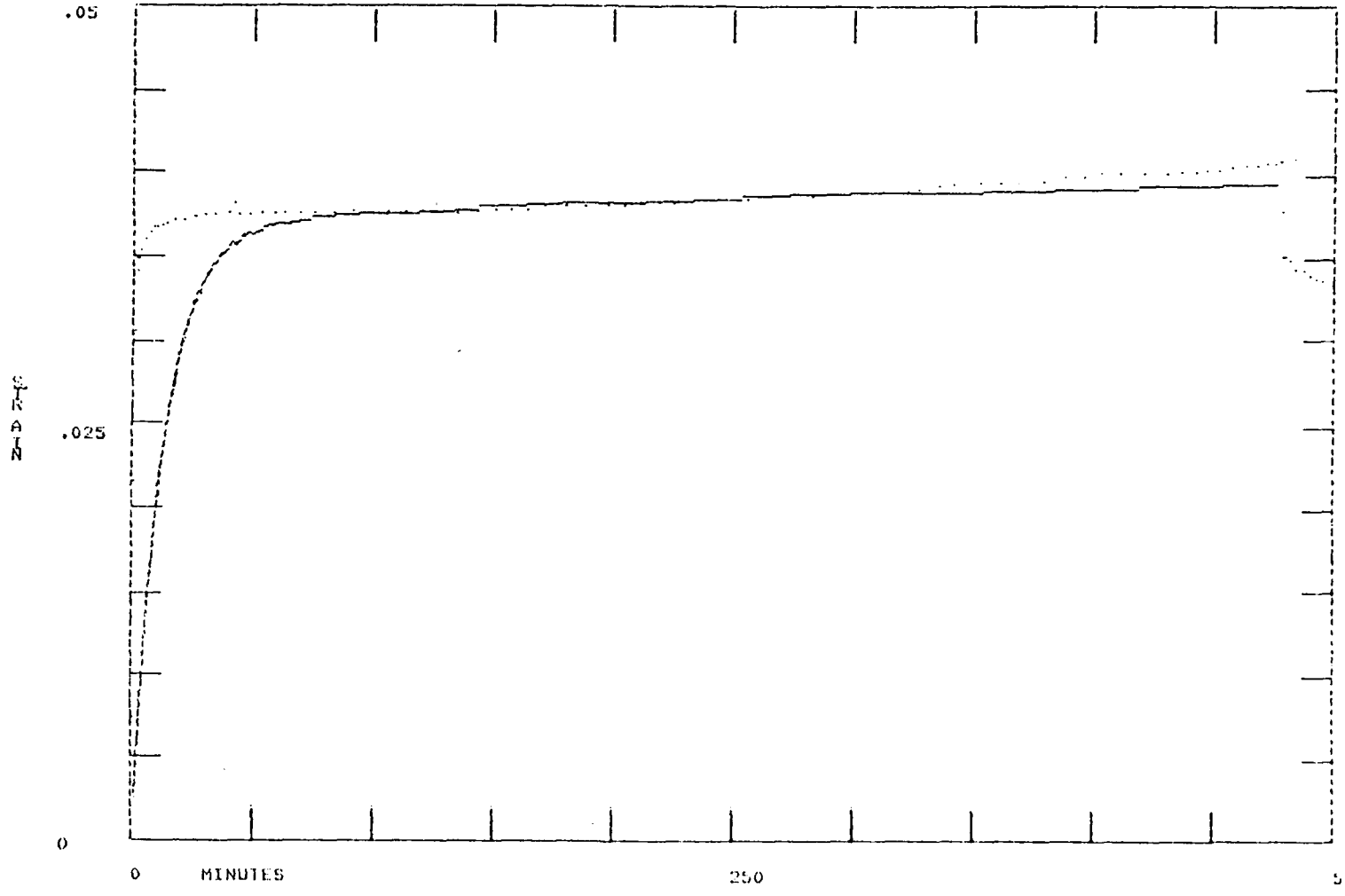
LK-08 TB-19 22 AUG 75 AREA = 0.12 SQ CM HEIGHT = 1.194 CM
DOTTED LINE: ORIGINAL DATA HEAVY LINE: MODEL PREDICTION



3-PARAMETER SOLID MODEL WITH VALUES OF
A1 = .049107, B1 = 9.708E-04, A2 = .035491

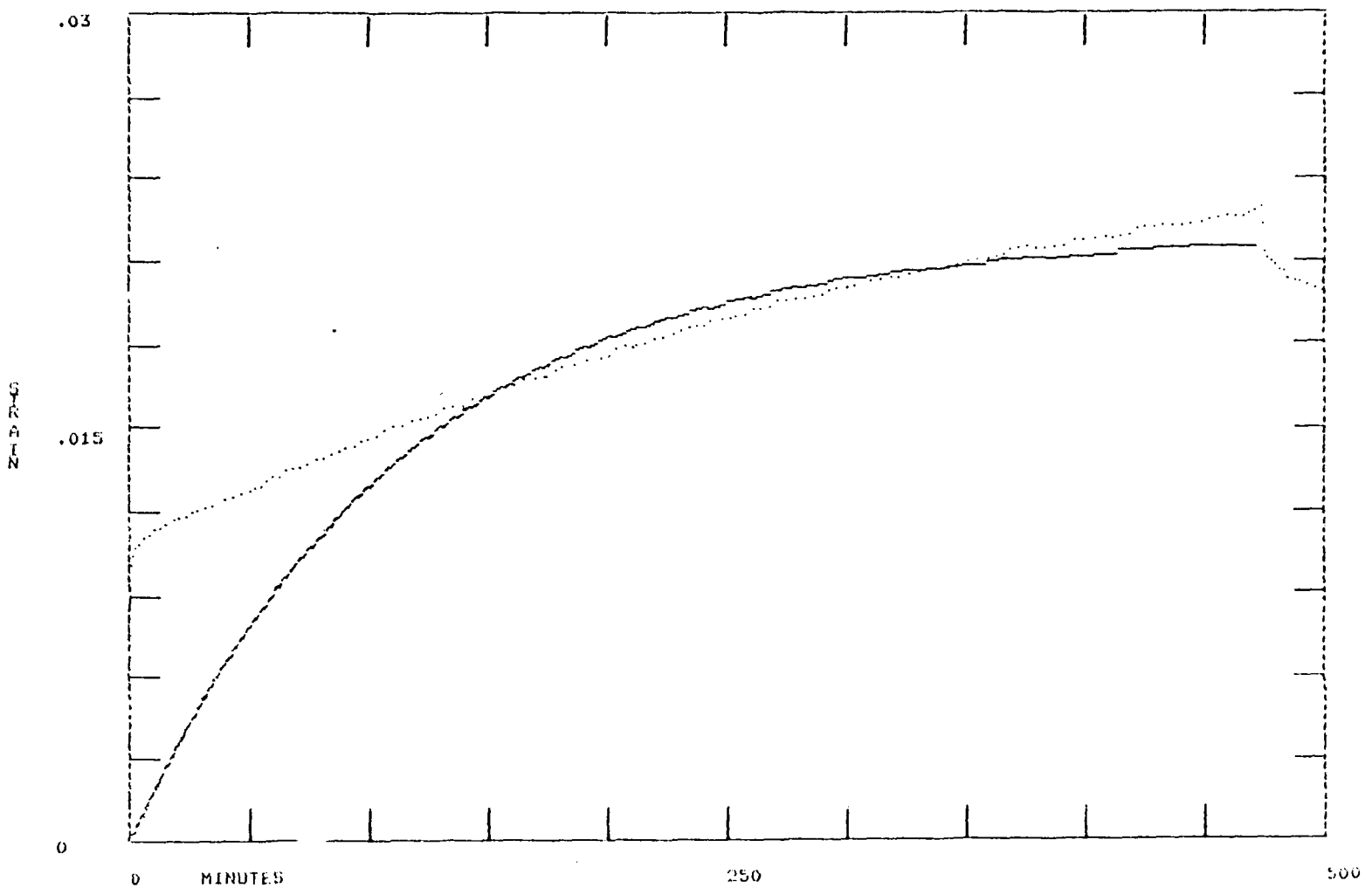
DELTA TIME = 8
ERROR (USING ALL POINTS): -0.312%
ERROR (IGNORING FIRST 3 POINTS): 1.024%

LA-08 TB-19 22 AUG 75 AREA = 0.12 SQ CM HEIGHT = 1.194 CM
DOTTED LINE: ORIGINAL DATA HEAVY LINE: MODEL PREDICTION



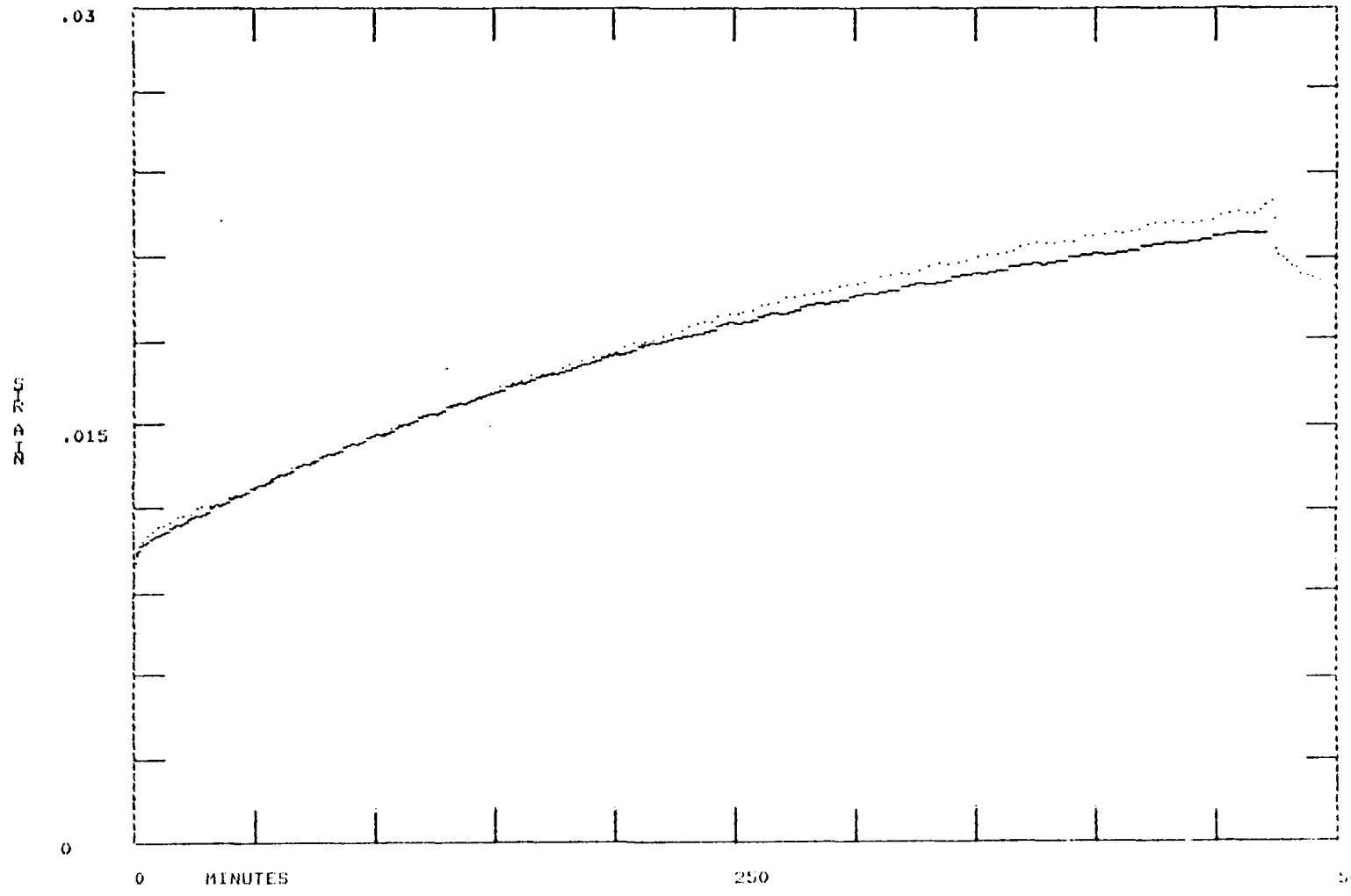
4-PARAMETER SOLID MODEL WITH VALUES OF
A1 = 3.5037E-03, B1 = 3.1859E-03, A2 = .036775, B2 = .0012224
DELTA TIME = 30
ERROR (USING ALL POINTS): 9.501%
ERROR (IGNORING FIRST 3 POINTS): 8.294%

LK-08 TB-T9 22 AUG 75 AREA = 0.12 SQ CM HEIGHT = 1.194 CM
DOTTED LINE: ORIGINAL DATA HEAVY LINE: MODEL PREDICTION



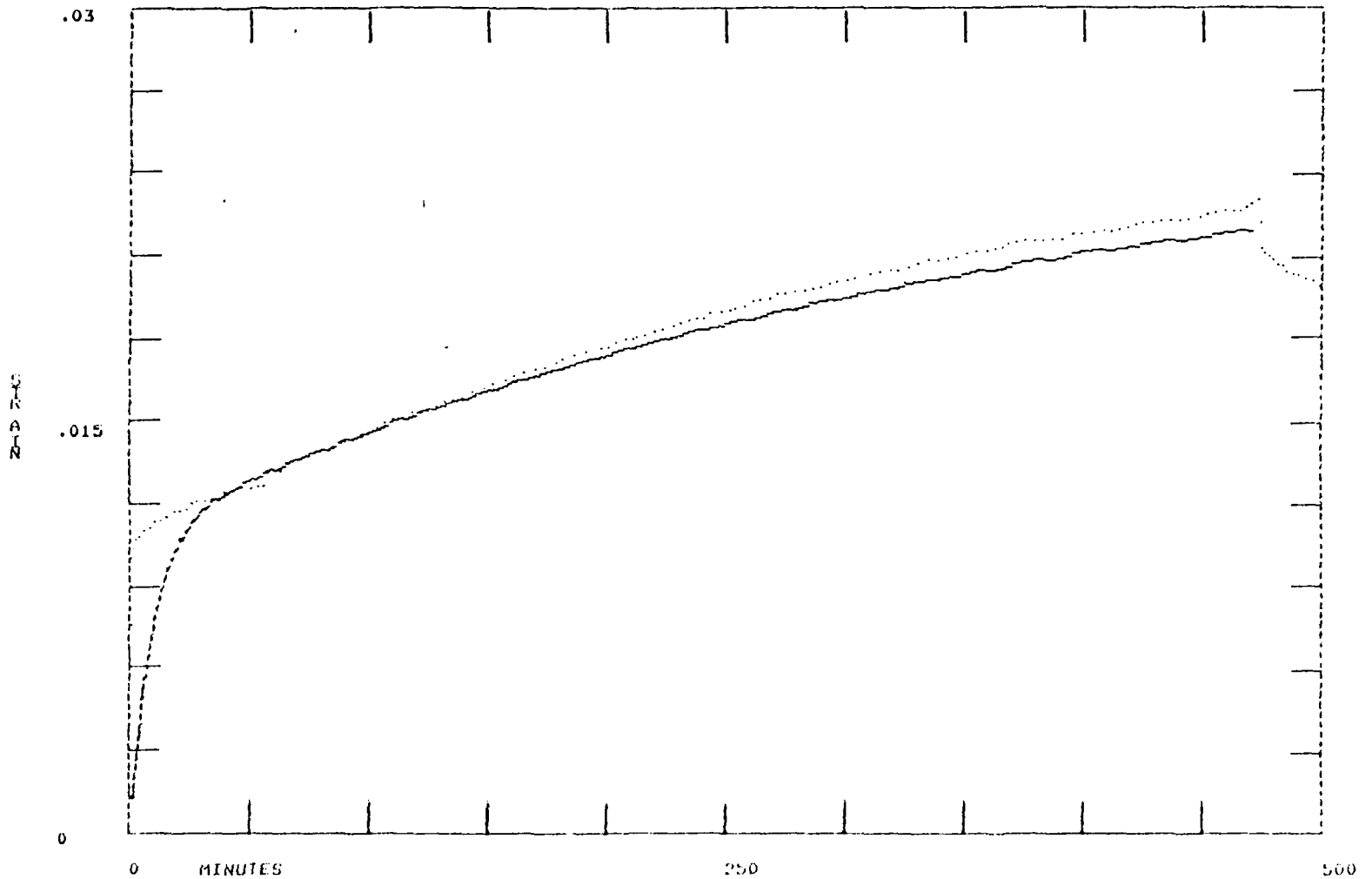
2-PARAMETER SOLID MODEL WITH VALUES OF
A1 = .0221876, B1 = 8.9334E-03, A2 = 0
DELTA TIME = 16
ERROR (USING ALL POINTS): 9.698%
ERROR (IGNORING FIRST 3 POINTS): 9.485%

LN-09 T9-T10 21 AUG 75 AREA = 7.78 SQ CM HEIGHT = 2.24 CM
DOTTED LINE: ORIGINAL DATA HEAVY LINE: MODEL PREDICTION



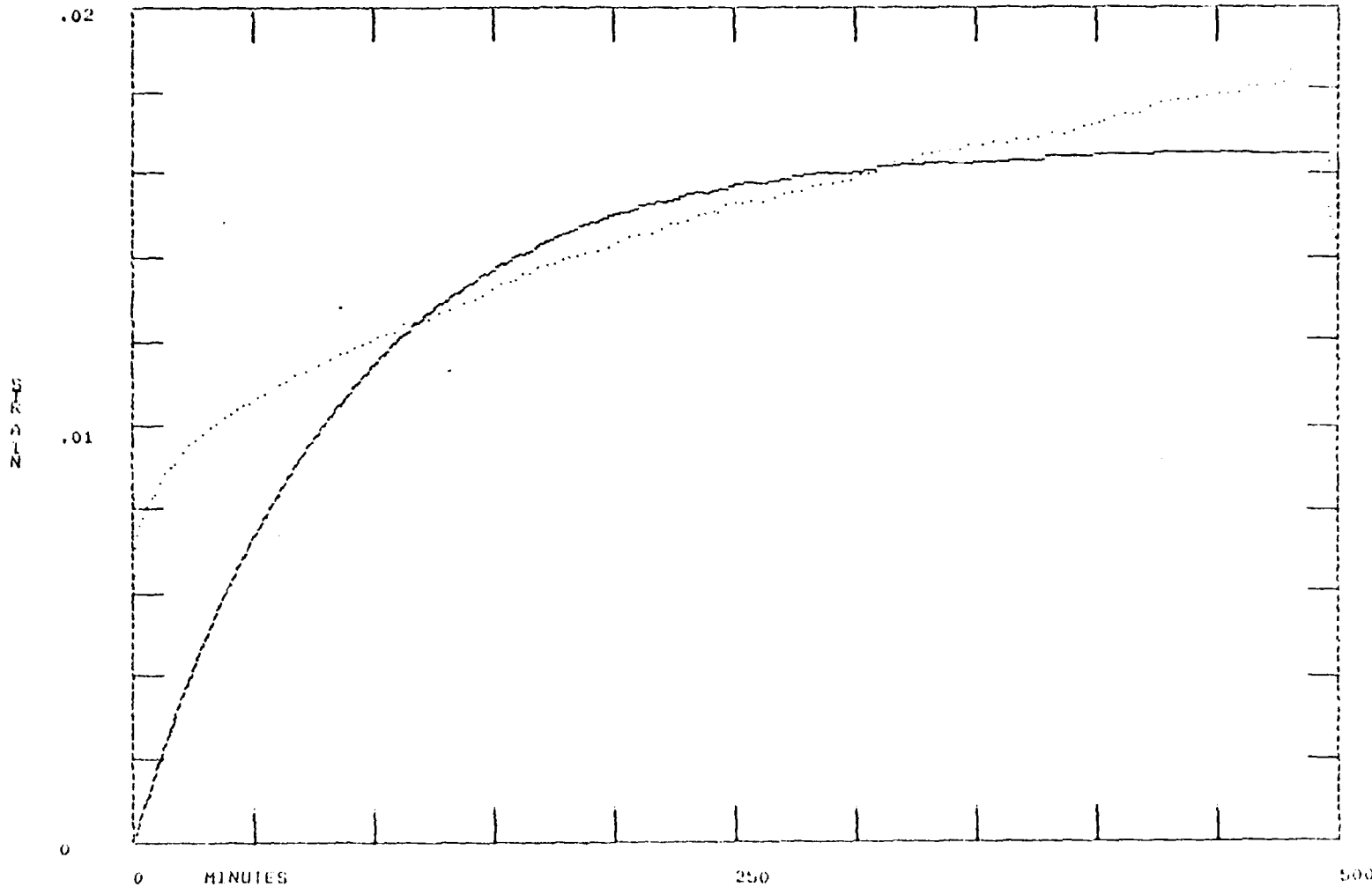
3-PARAMETER SOLID MODEL WITH VALUES OF
A1 = .025143, B1 = 3.2212E-03, A2 = .010609
DELTA TIME = 30
ERROR (USING ALL POINTS): 1.098%
ERROR (IGNORING FIRST 3 POINTS): 1.218%

LK-09 T9-T10 21 AUG 75 AREA = 7.78 SQ CM HEIGHT = 2.24 CM
DOTTED LINE: ORIGINAL DATA HEAVY LINE: MODEL PREDICTION



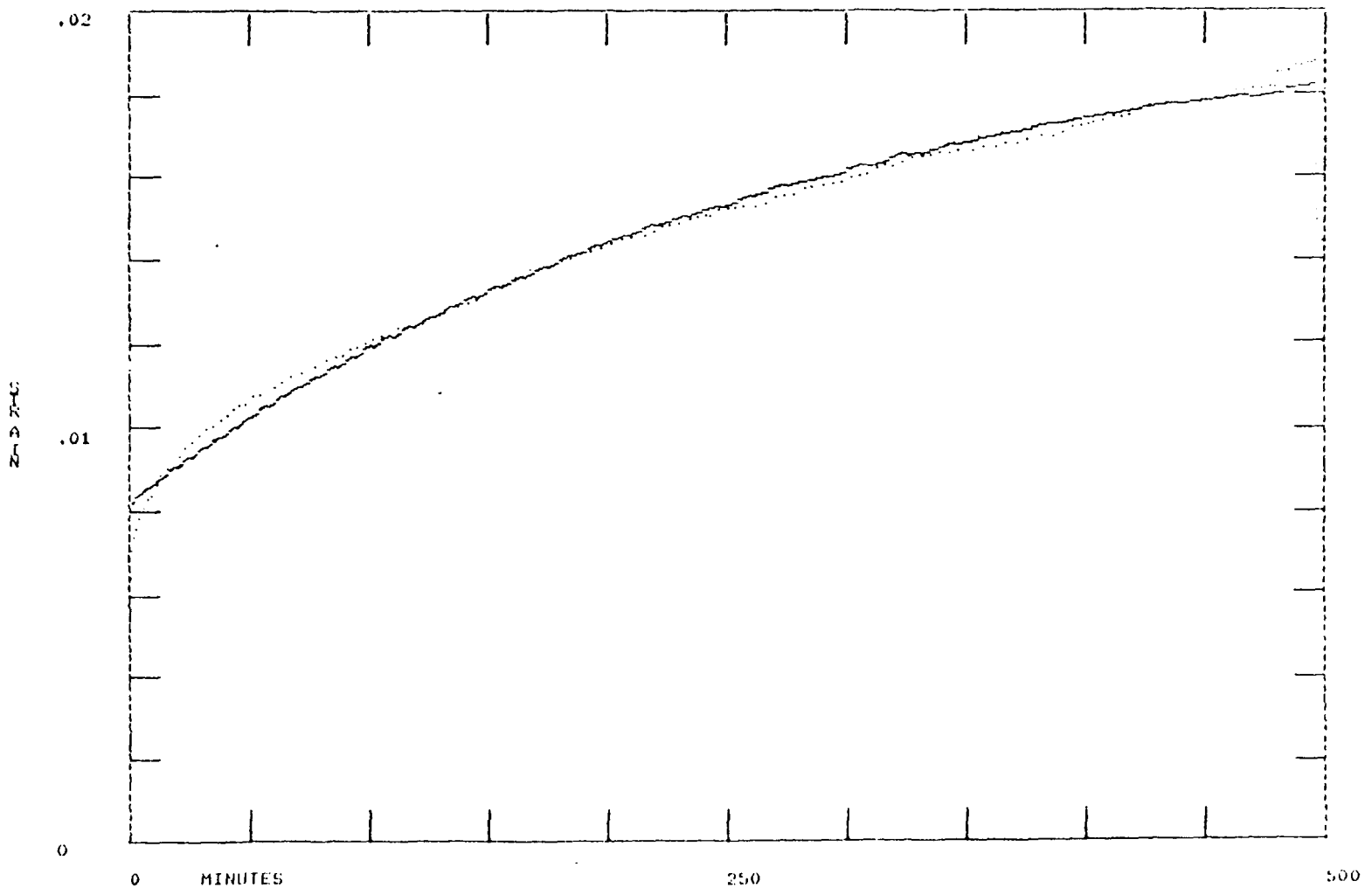
4-PARAMETER SOLID MODEL WITH VALUES OF
A1 = .010934, R1 = .110983, A2 = .015064, R2 = 2.7868E-03
DELTA TIME = 16
ERROR (USING ALL POINTS): 4.295%
ERROR (IGNORING FIRST 3 POINTS): 4.610%

LK-09 T9-T10 21 AUG 75 AREA = 7.70 SQ CM HEIGHT = 2.24 CM
DOTTED LINE: ORIGINAL DATA HEAVY LINE: MODEL PREDICTION



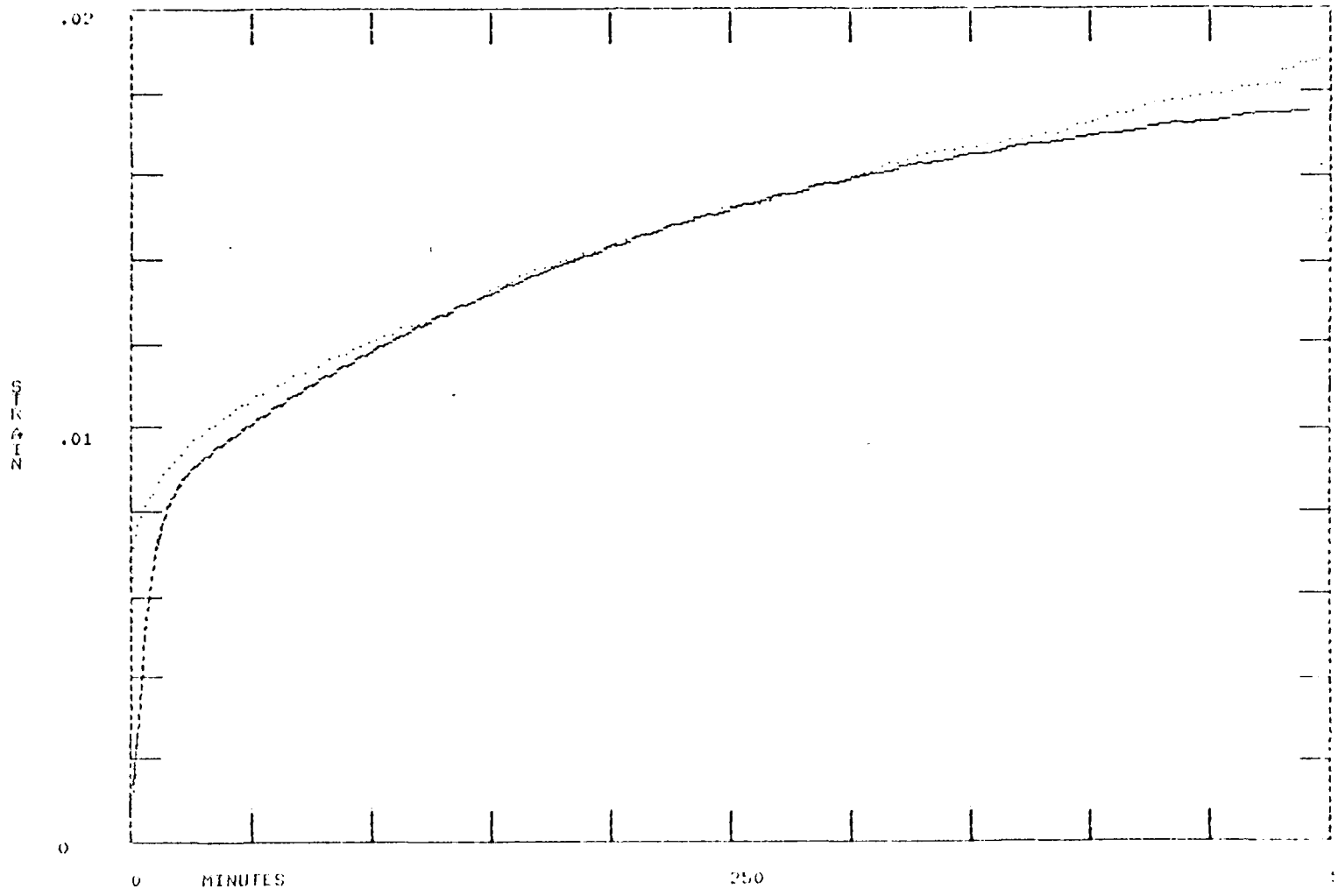
2-PARAMETER SOLID MODEL WITH VALUES OF
A1 = .016593, B1 = .011243, A2 = 0
DELTA TIME = 3.6
ERROR (USING ALL POINTS): 2.004%
ERROR (IGNORING FIRST 3 POINTS): 8.620%

LK-10 T10-T11 04 AUG 75 ARE = 8.96 SQ CM HEIGHT = 3.92 CM
DOTTED LINE: ORIGINAL DATA HEAVY LINE: MODEL PREDICTION



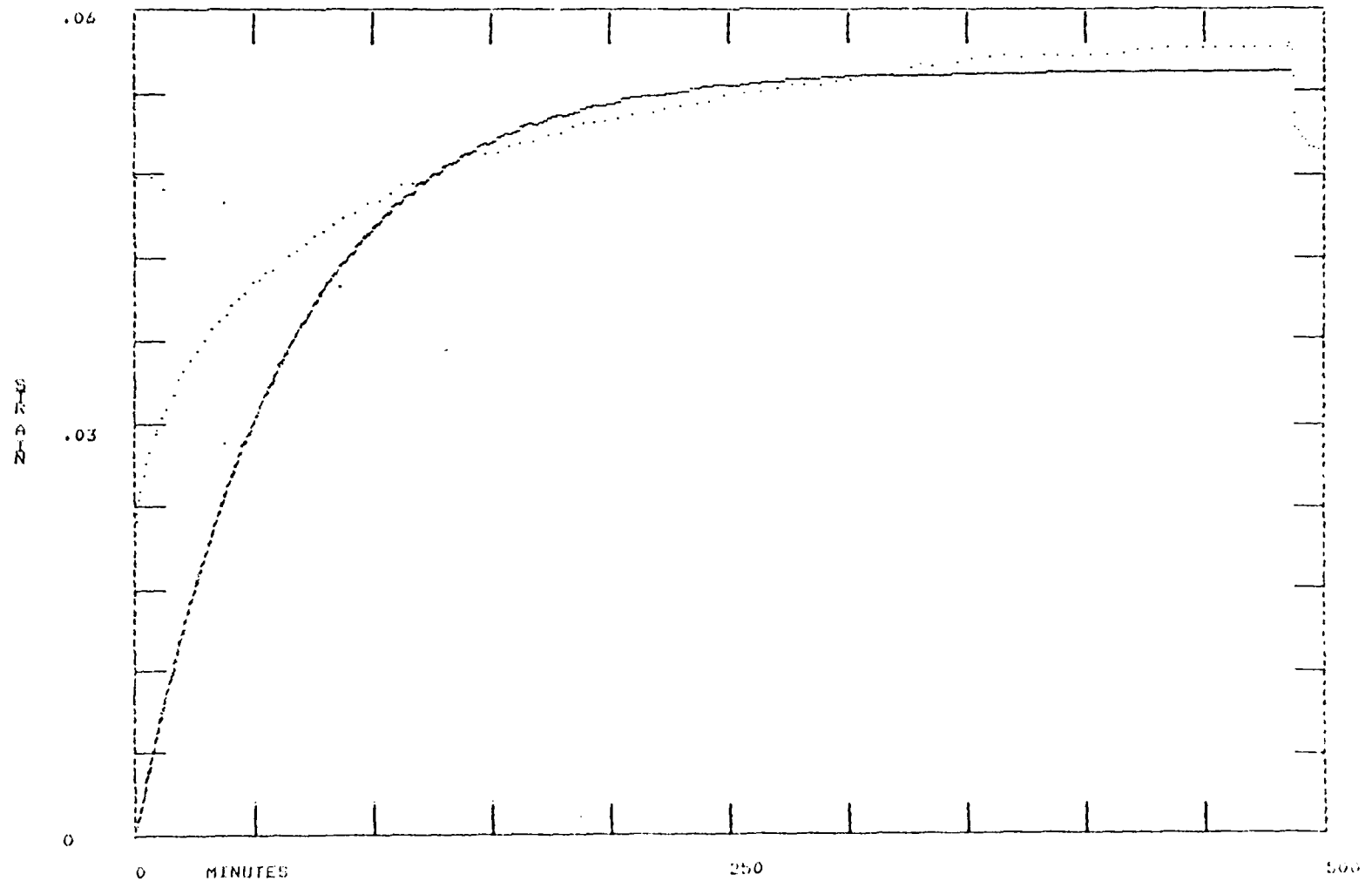
3-PARAMETER SOLID MODEL WITH VALUES OF
A1 = .0200492, B1 = 3.7025E-03, A2 = .0083254
DELTA TIME = 30
ERROR (USING ALL POINTS): -0.333%
ERROR (IGNORING FIRST 3 POINTS): 0.031%

LK-10 T10-T11 04 AUG 75 AREA = 0.96 SQ CM HEIGHT = 3.92 CM
DOTTED LINE: ORIGINAL DATA HEAVY LINE: MODEL PREDICTION



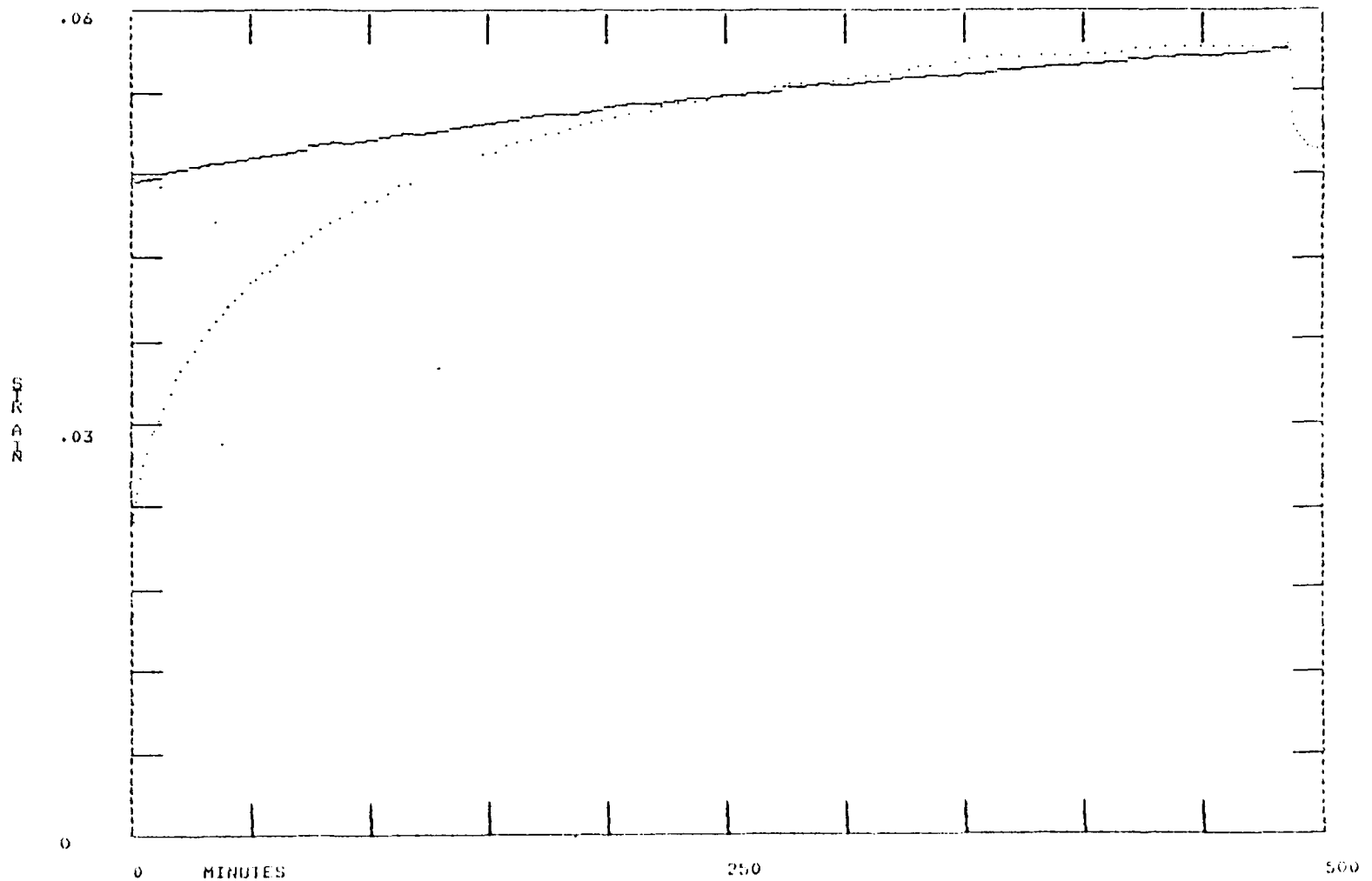
4-PARAMETER SOLID MODEL WITH VALUES OF
A1 = .0108345, B1 = 4.42046E-03, A2 = 7.95111E-03, B2 = .122139
DELTA TIME = 1.6
ERROR (USING ALL POINTS): 35.65922%
ERROR (IGNORING FIRST 3 POINTS): 35.3081%

LX-10 T10-T11 04 AUG 75 AREA = 8.96 SQ CM HEIGHT = 3.92 CM
DOTTED LINE: ORIGINAL DATA HEAVY LINE: MODEL PREDICTION



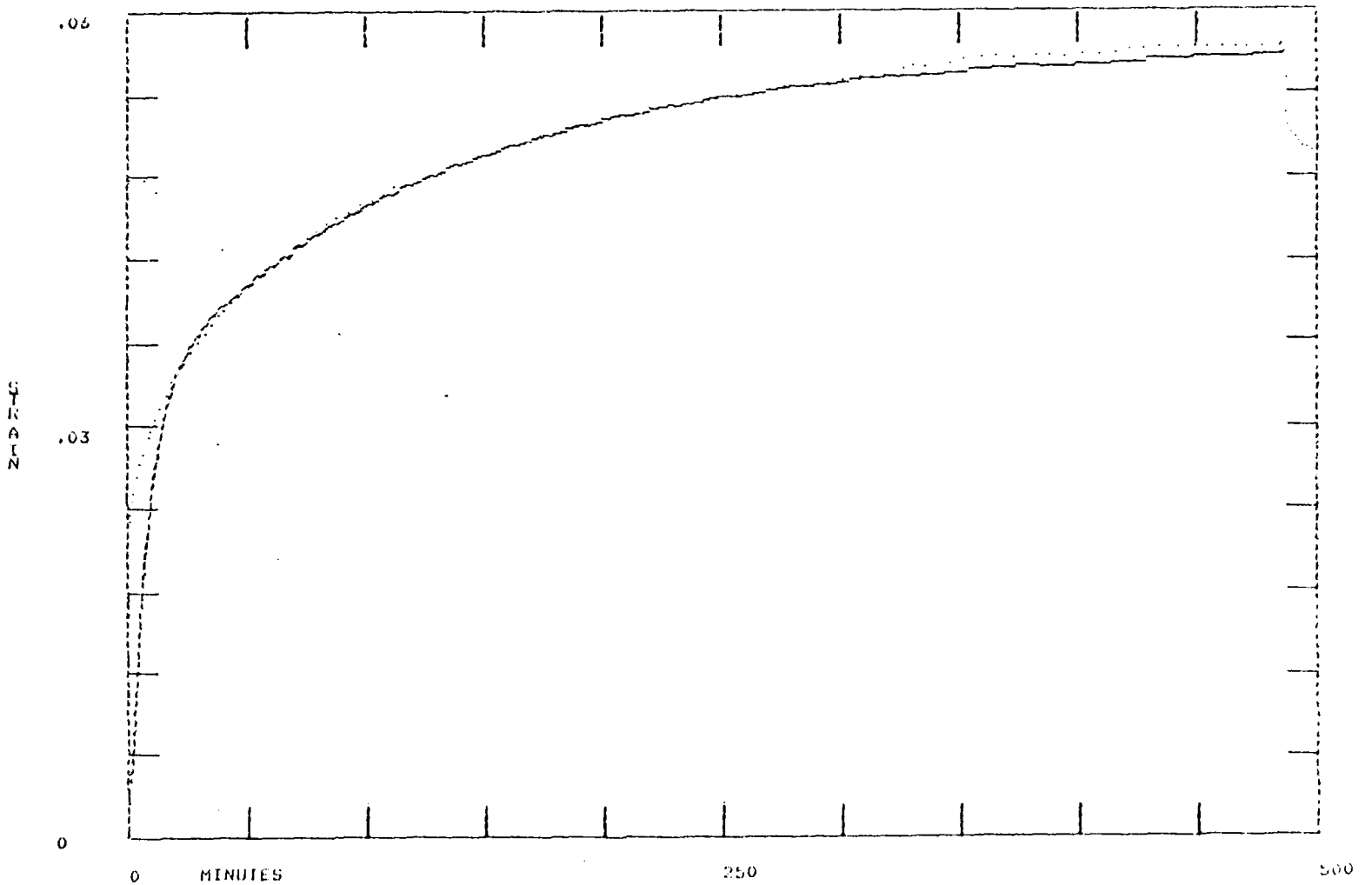
2-PARAMETER SOLID MODEL WITH VALUES OF
A1 = .0556837, B1 = .0157955, A2 = 0
DELTA TIME = 8
ERROR (USING ALL POINTS): 15.589%
ERROR (IGNORING FIRST 3 POINTS): 15.240%

LN-16 T2-T3 06 JUN 75 AREA = 5.79 50 CM HEIGHT = 2.43 CM
DOTTED LINE: ORIGINAL DATA HEAVY LINE: MODEL PREDICTION



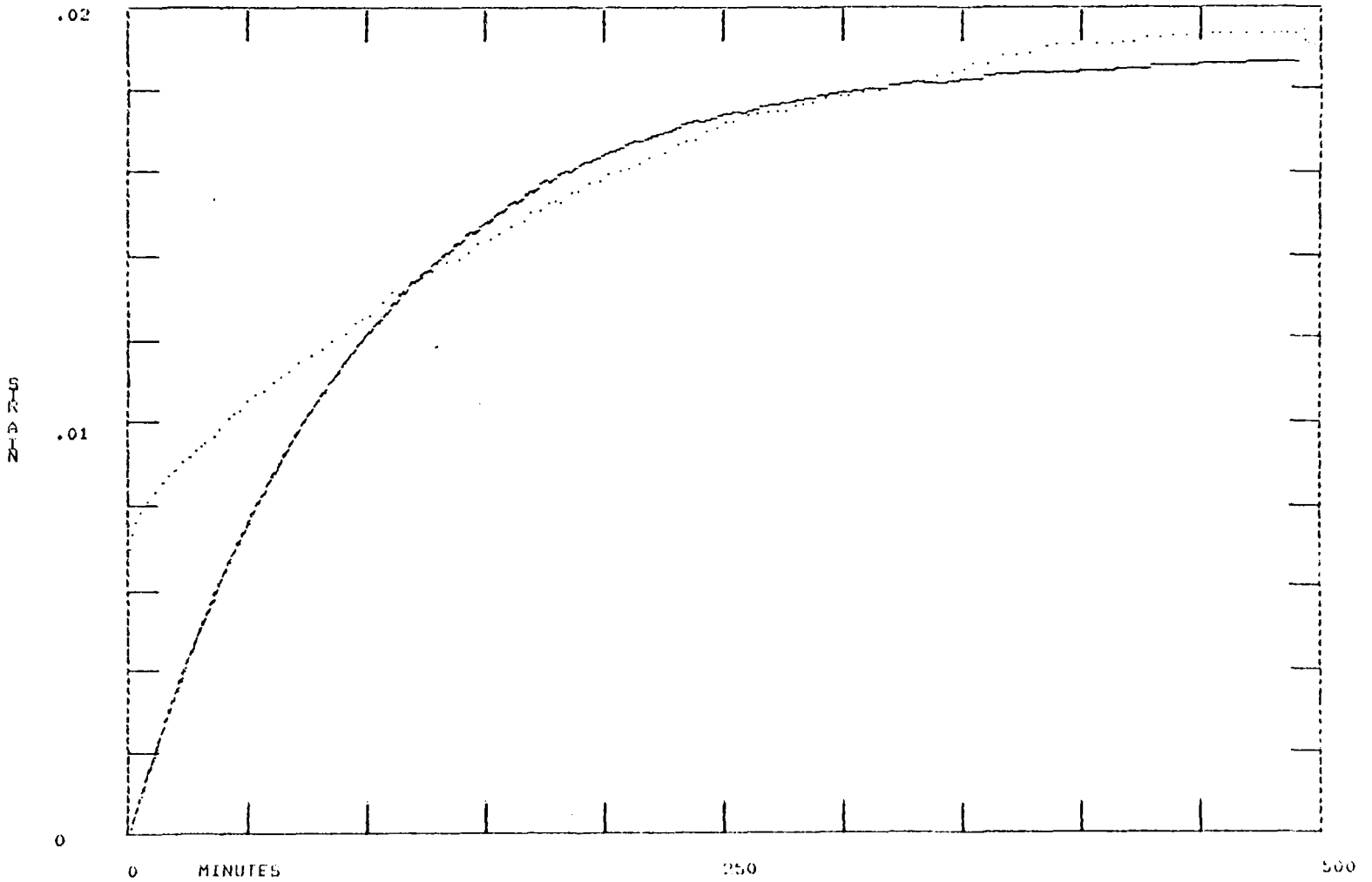
3-PARAMETER SOLID MODEL WITH VALUES OF
A1 = .06225, X1 = 2.1092E-03, A2 = .049768
DELTA TIME = 4
ERROR (USING ALL POINTS): -2.692%
ERROR (IGNORING FIRST 3 POINTS): -8.3562%

LN-16 12-13 06 JUN 75 AREA = 5.79 SQ CM HEIGHT = 2.43 CM
DOTTED LINE: ORIGINAL DATA HEAVY LINE: MODEL PREDICTION



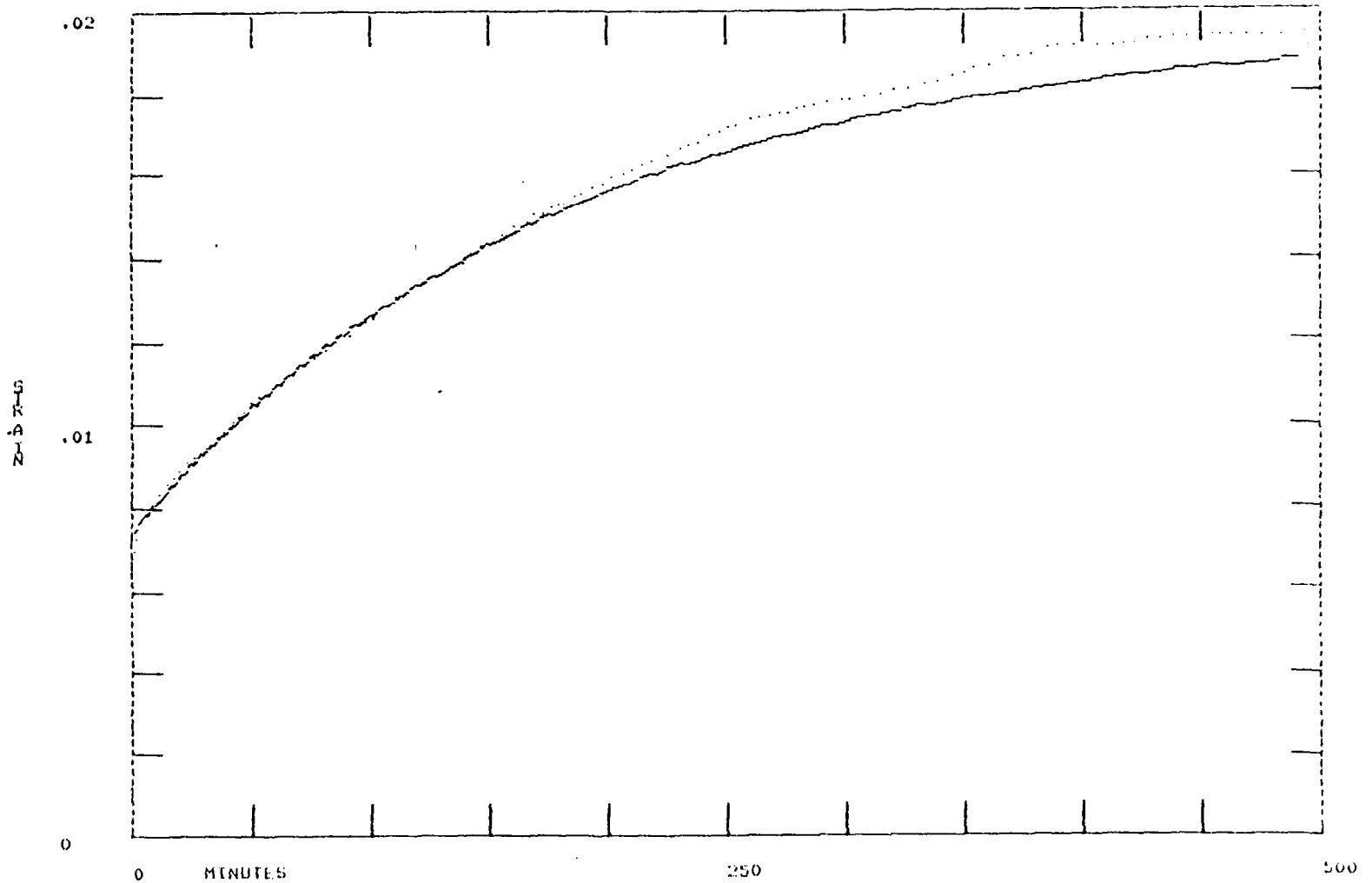
4-PARAMETER SOLID MODEL WITH VALUES OF
A1 = .032081, B1 = .135525, A2 = .025168, B2 = 7.89941E-03
DELTA TIME = 4
ERROR (USING ALL POINTS): 6.247%
ERROR (IGNORING FIRST 3 POINTS): 6.319%

LN-16 T2-T3 06 JUN 75 AREA = 5.79 SQ CM HEIGHT = 2.43 CM
DOTTED LINE: ORIGINAL DATA HEAVY LINE: MODEL PREDICTION



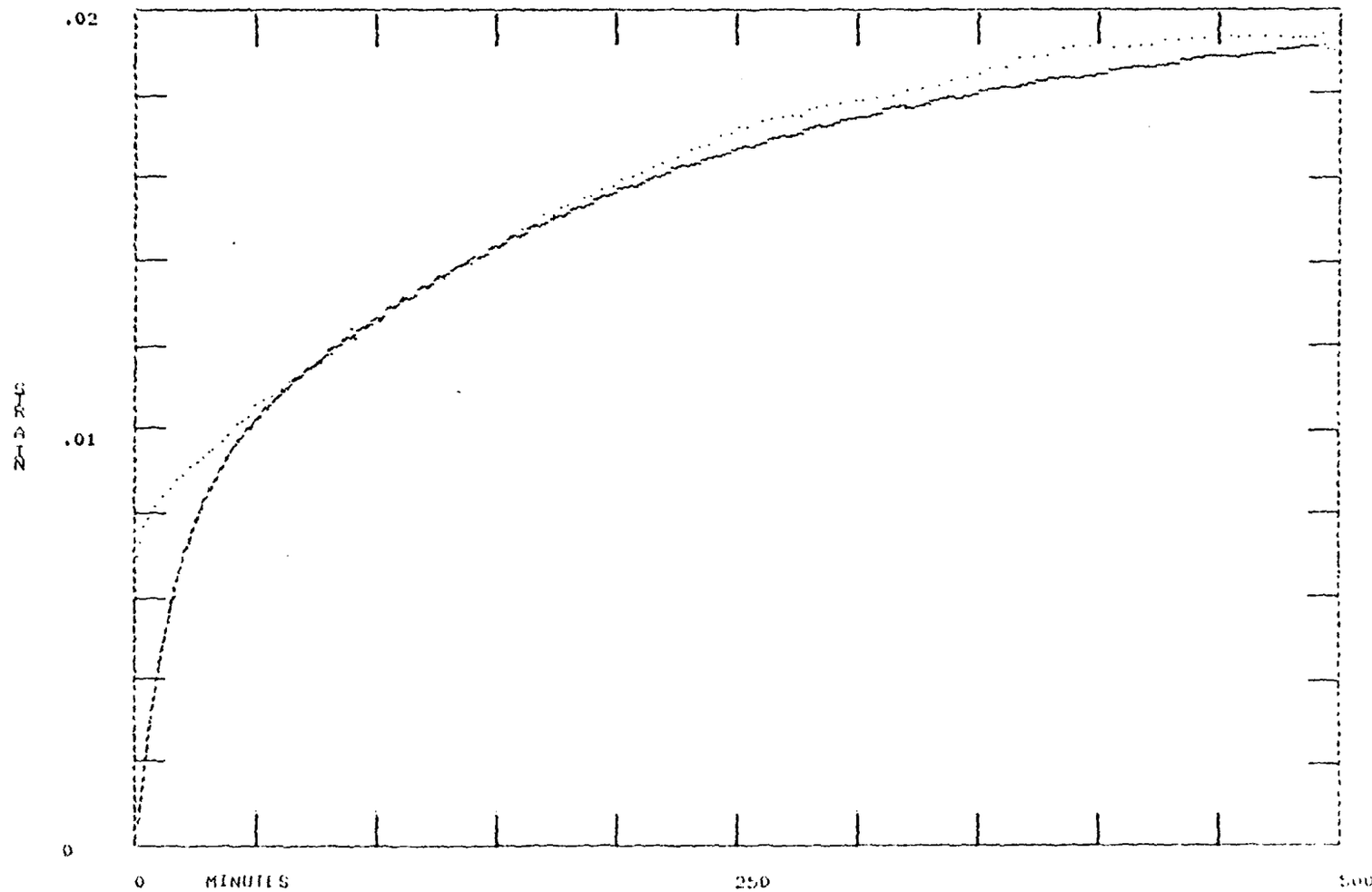
2-PARAMETER SOLID MODEL WITH VALUES OF
A1 = .018781, B1 = .010401, A2 = 0
DELTA TIME = 16
ERROR (USING ALL POINTS): 7.401%
ERROR (IGNORING FIRST 3 POINTS): 5.951%

LR-17 T3-T4 09 SEP 75 AREA = 5.15 SQ CM HEIGHT = 2.585 CM
DOTTED LINE: ORIGINAL DATA HEAVY LINE: MODEL PREDICTION



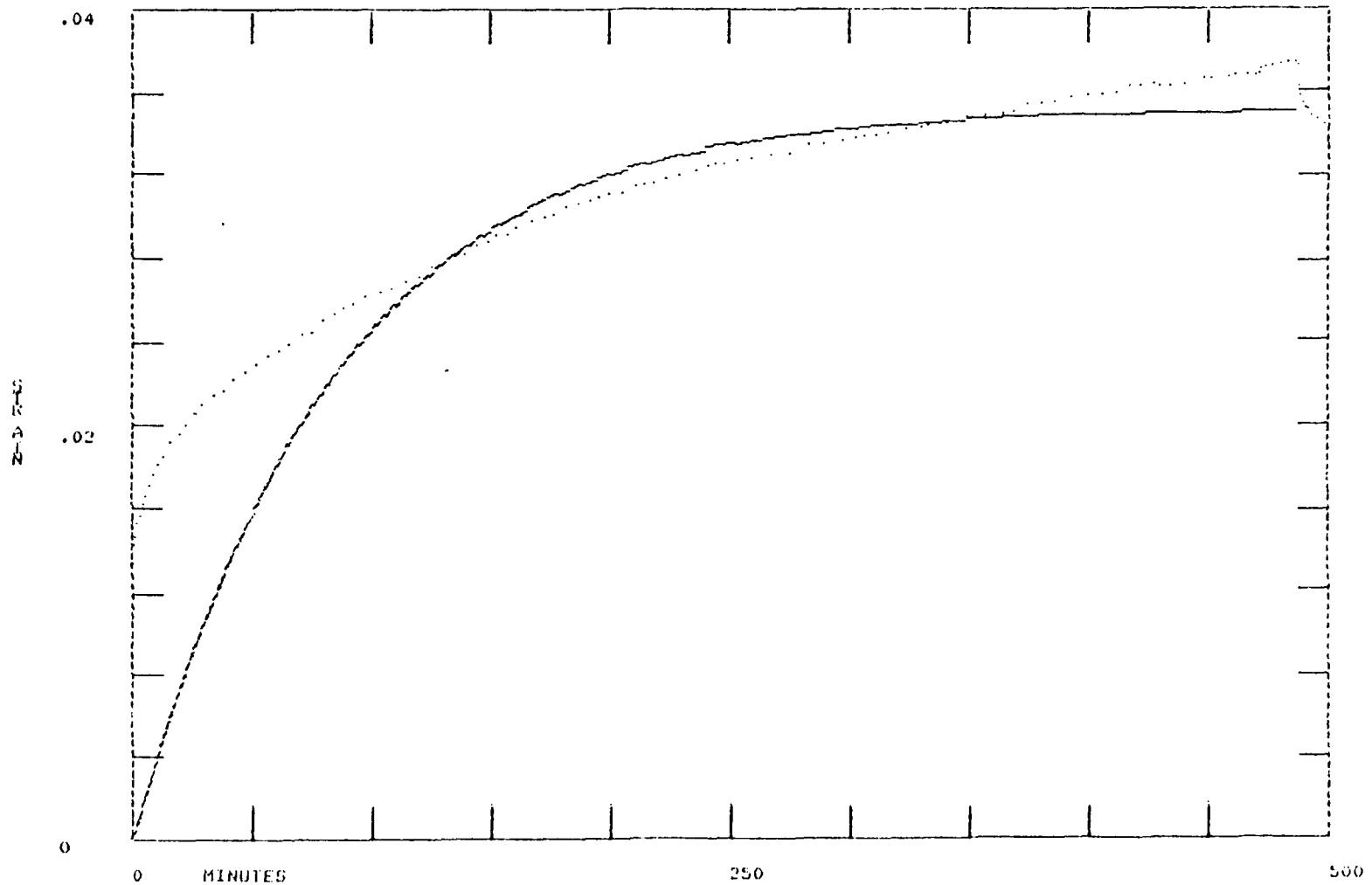
3-PARAMETER SOLID MODEL WITH VALUES OF
A1 = .0192618, B1 = 5.55338E-03, A2 = 7.49022E-03
DELTA TIME = 4
ERROR (USING ALL POINTS): 1.872%
ERROR (IGNORING FIRST 3 POINTS): 2.232%

LN-17 T3-T4 09 SEP 75 AREA = 5.15 SQ CM HEIGHT = 2.585 CM
DOTTED LINE: ORIGINAL DATA HEAVY LINE: MODEL PREDICTION



4-PARAMETER SOLID MODEL WITH VALUES OF
A1 = .012466, B1 = 5.0791E-03, A2 = 2.7114E-03, B2 = .0692448
DELTA TIME = 16
ERROR (USING ALL POINTS): 4.598%
ERROR (IGNORING FIRST 3 POINTS): 4.151%

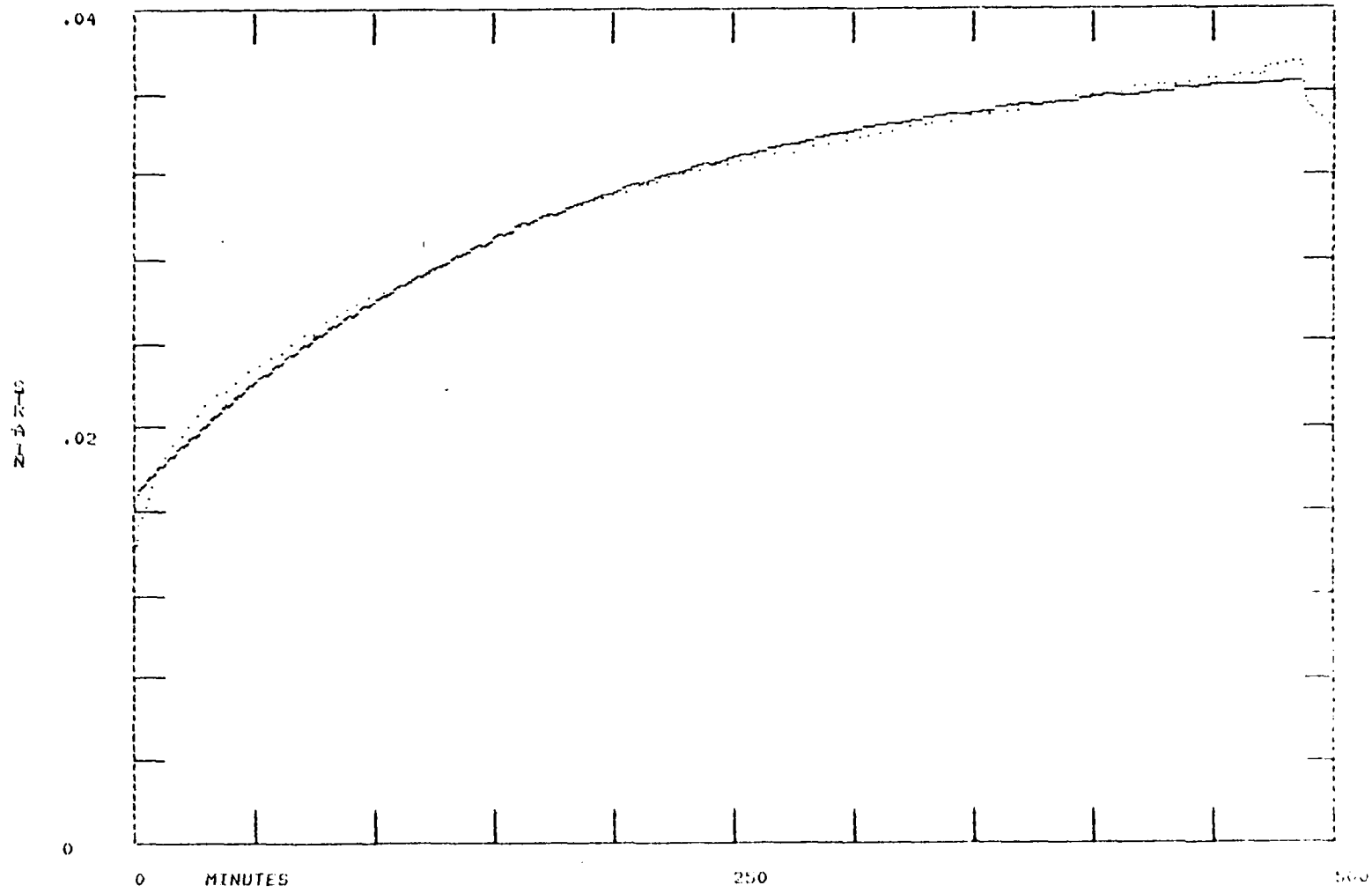
LN-17 T3-T4 09 SEP 75 AREA = 5.15 SQ CM HEIGHT = 2.505 CM
DOTTED LINE: ORIGINAL DATA HEAVY LINE: MODEL PREDICTION



2-PARAMETER SOLID MODEL WITH VALUES OF
A1 = .035256, B1 = .011995, A2 = 0

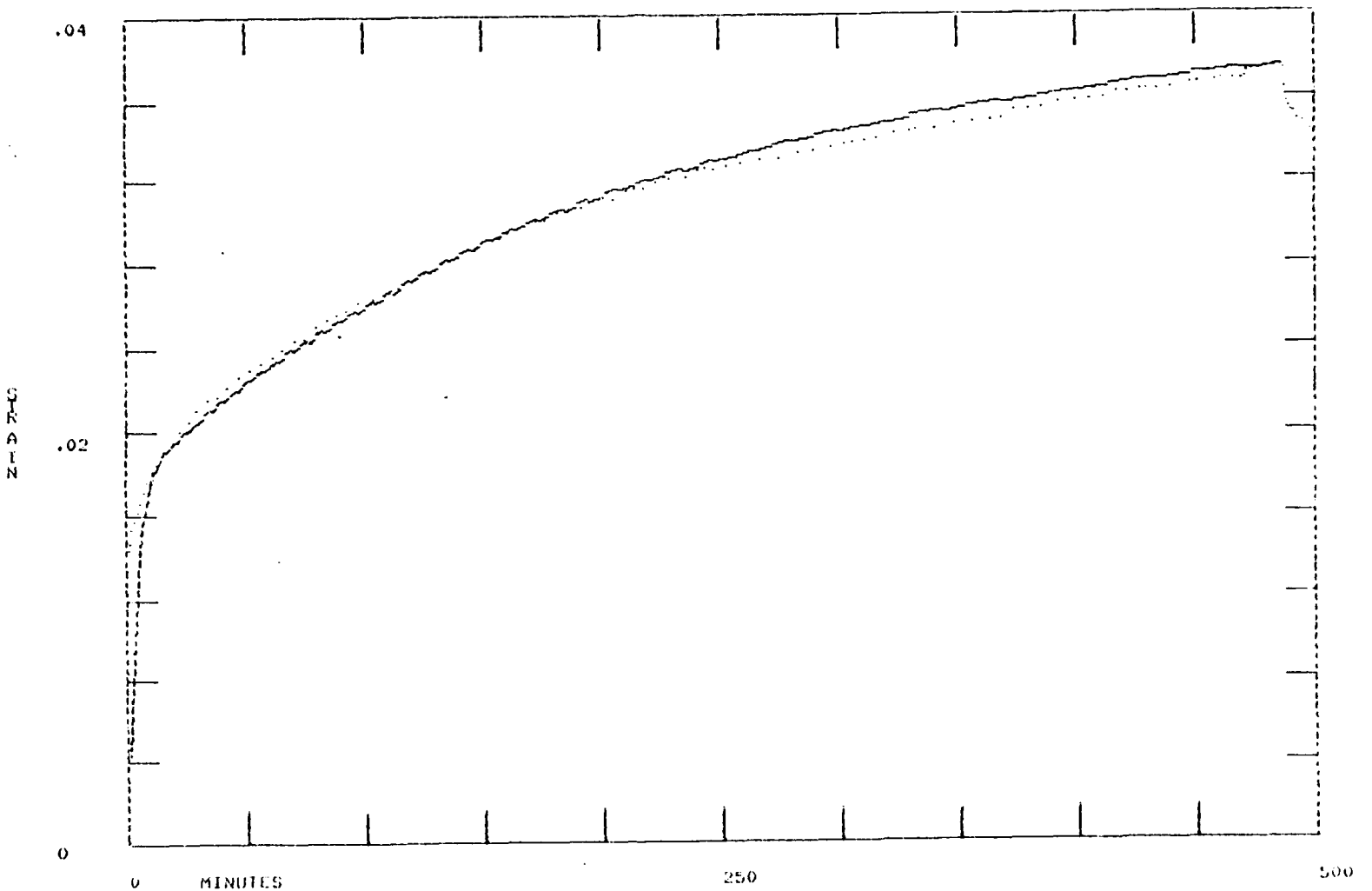
DELTA TIME = 16
ERROR (USING ALL POINTS): 9.830%
ERROR (IGNORING FIRST 3 POINTS): 9.196%

LN-18 14:15 12 AUG 75 AREA = 5.31 SQ CM HEIGHT = 2.445 CM
DOTTED LINE: ORIGINAL DATA HEAVY LINE: MODEL PREDICTION



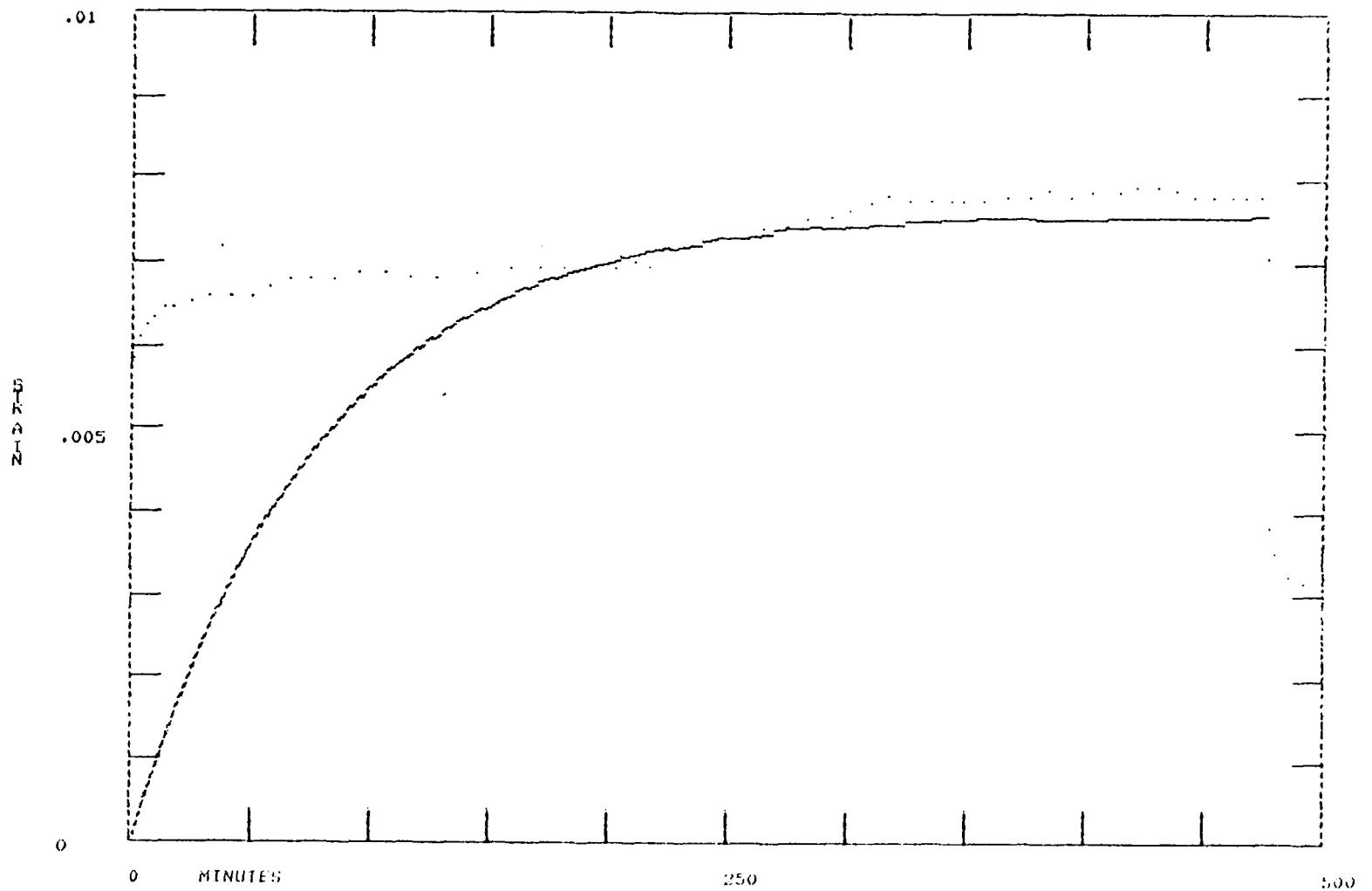
3-PARAMETER SOLID MODEL WITH VALUES OF
A1 = .032911, B1 = .005742, A2 = .016826
DELTA TIME = 4
ERROR (USING ALL POINTS): -0.200%
ERROR (IGNORING FIRST 3 POINTS): 0.128%

LK-18 T4-T5 12 AUG 75 AREA = 5.31 SQ CM HEIGHT = 2.445 CM
DOTTED LINE: ORIGINAL DATA HEAVY LINE: MODEL PREDICTION



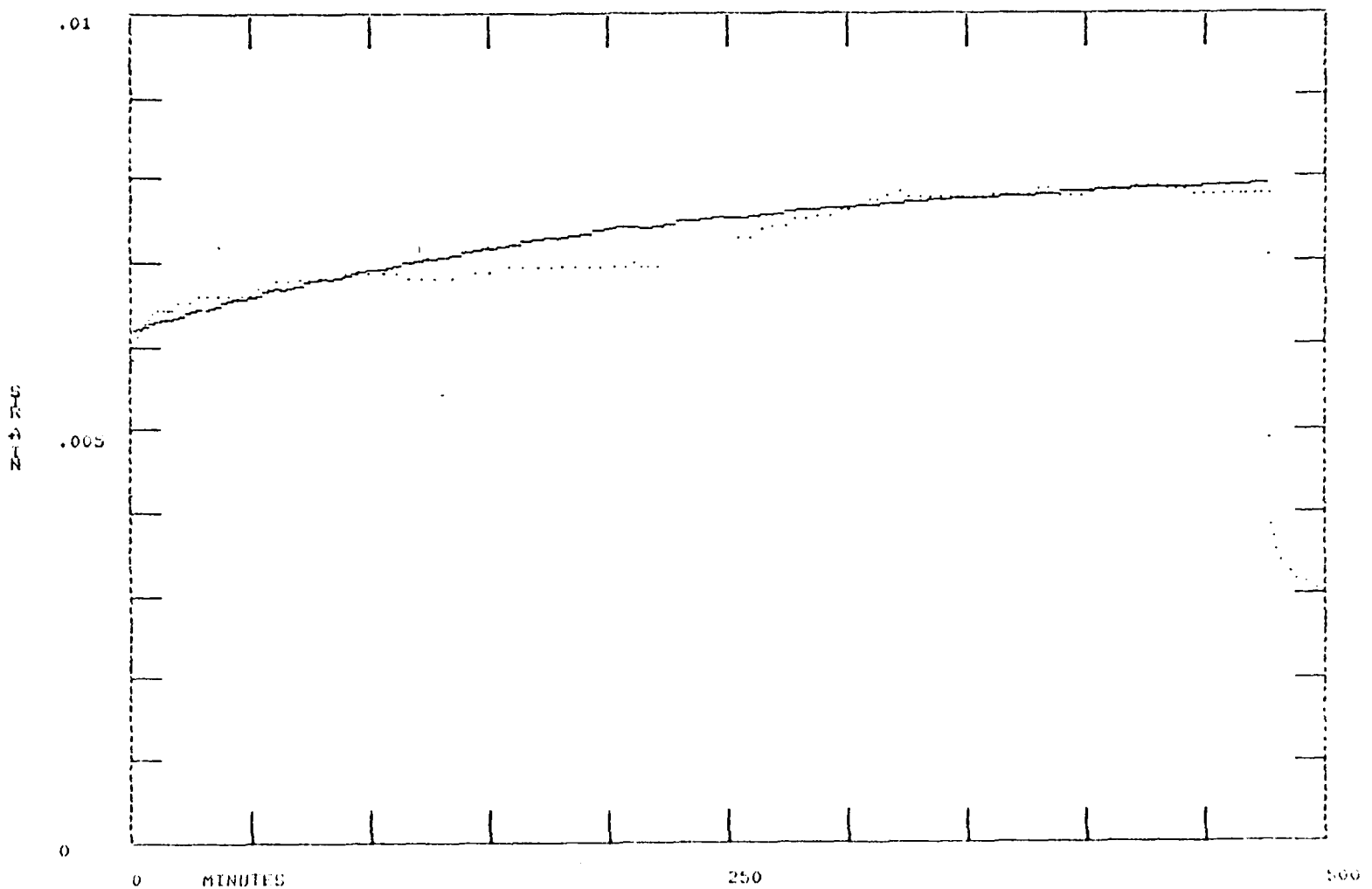
4-PARAMETER SOLID MODEL WITH VALUES OF
A1 = .012501, B1 = .29601, A2 = .022200, B2 = 4.8998E-03
DELTA TIME = 4
ERROR (USING ALL POINTS): 0.909%
ERROR (IGNORING FIRST 3 POINTS): 0.342%

LN-18 14:15 12 AUG 75 AREA = 5.31 SQ CM HEIGHT = 2.445 CM
DOTTED LINE: ORIGINAL DATA HEAVY LINE: MODEL PREDICTION



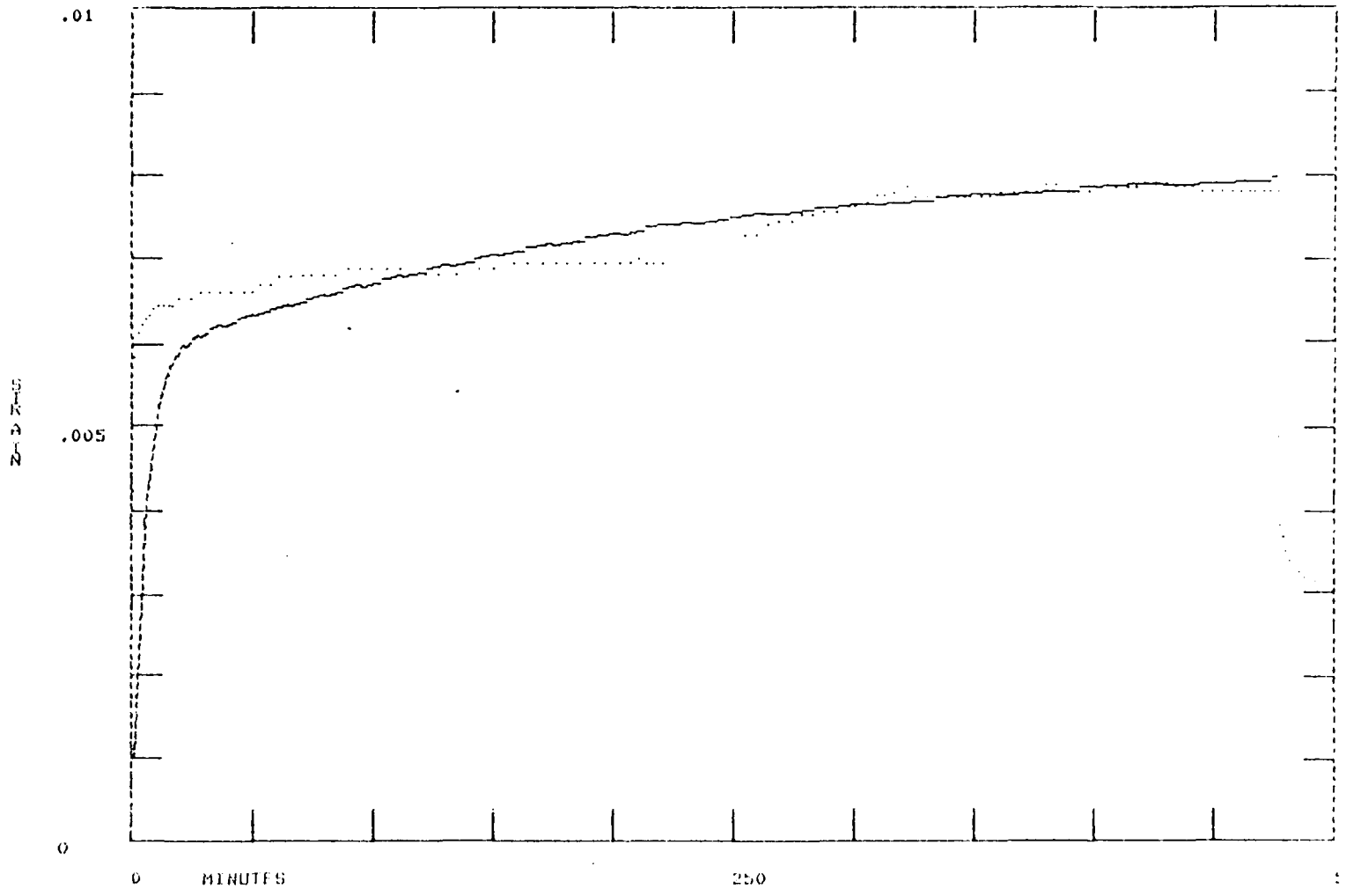
2-PARAMETER SOLID MODEL WITH VALUES OF
A1 = 7.5984E-03, B1 = .0129
DELTA TIME = 4
ERROR (USING ALL POINTS): 18.291%
ERROR (IGNORING FIRST 3 POINTS): 15.365%

LN-19 T5-T6 11 AUG 75 AREA = 5.8 SQ CM WEIGHT = 2.24 GM
DOTTED LINE: ORIGINAL DATA HEAVY LINE: MODEL PREDICTION



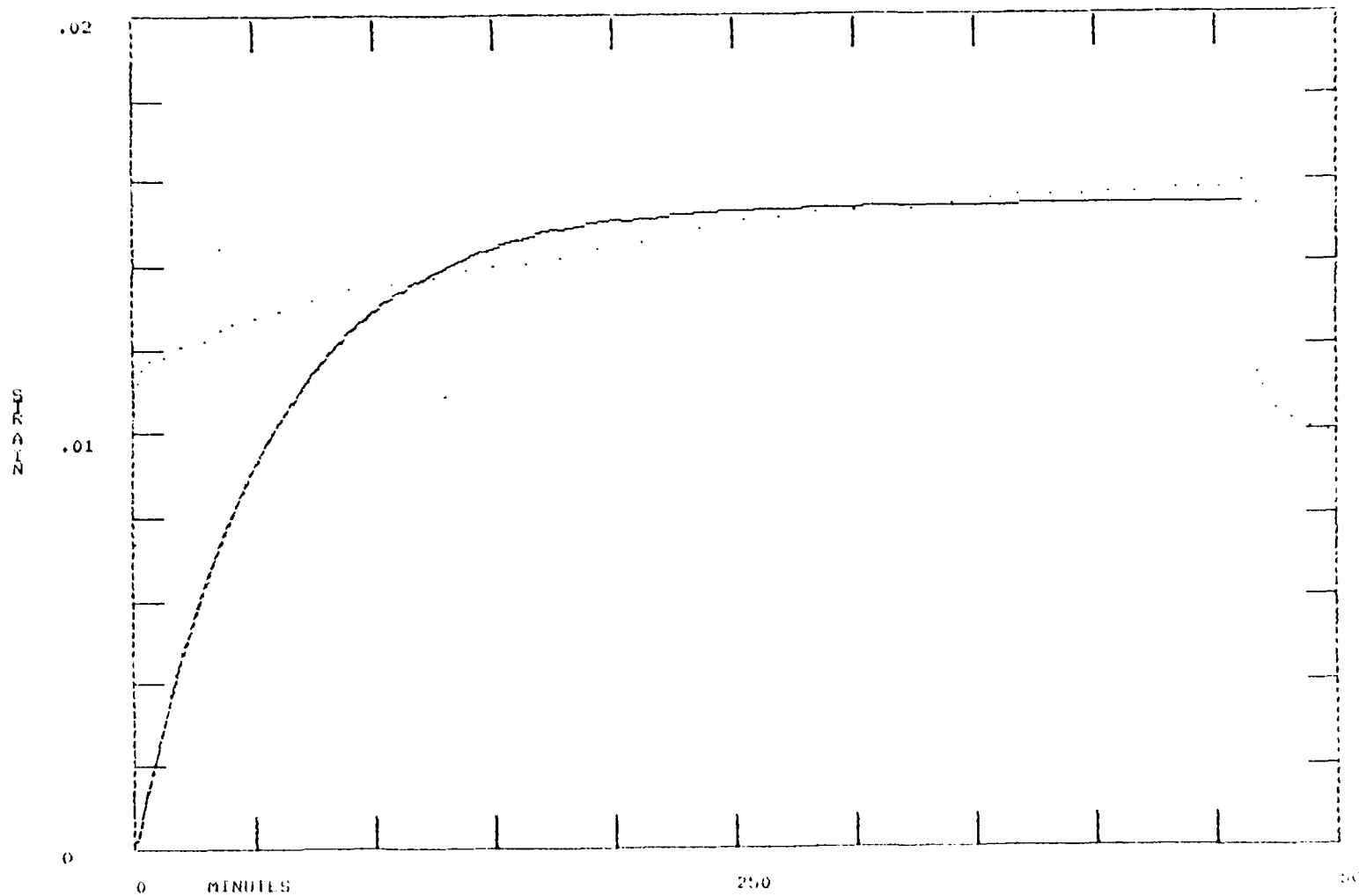
3-PARAMETER SOLID MODEL WITH VALUES OF
A1 = 8.1835E-03, B1 = 4.4625E-03, A2 = .006219
DELTA TIME = 4
ERROR (USING ALL POINTS): -1.941%
ERROR (IGNORING FIRST 3 POINTS): -1.139%

LN-19 T5-T6 11 AUG 75 AREA = 5.8 SQ CM HEIGHT = 2.24 CM
DOTTED LINE: ORIGINAL DATA HEAVY LINE: MODEL PREDICTION



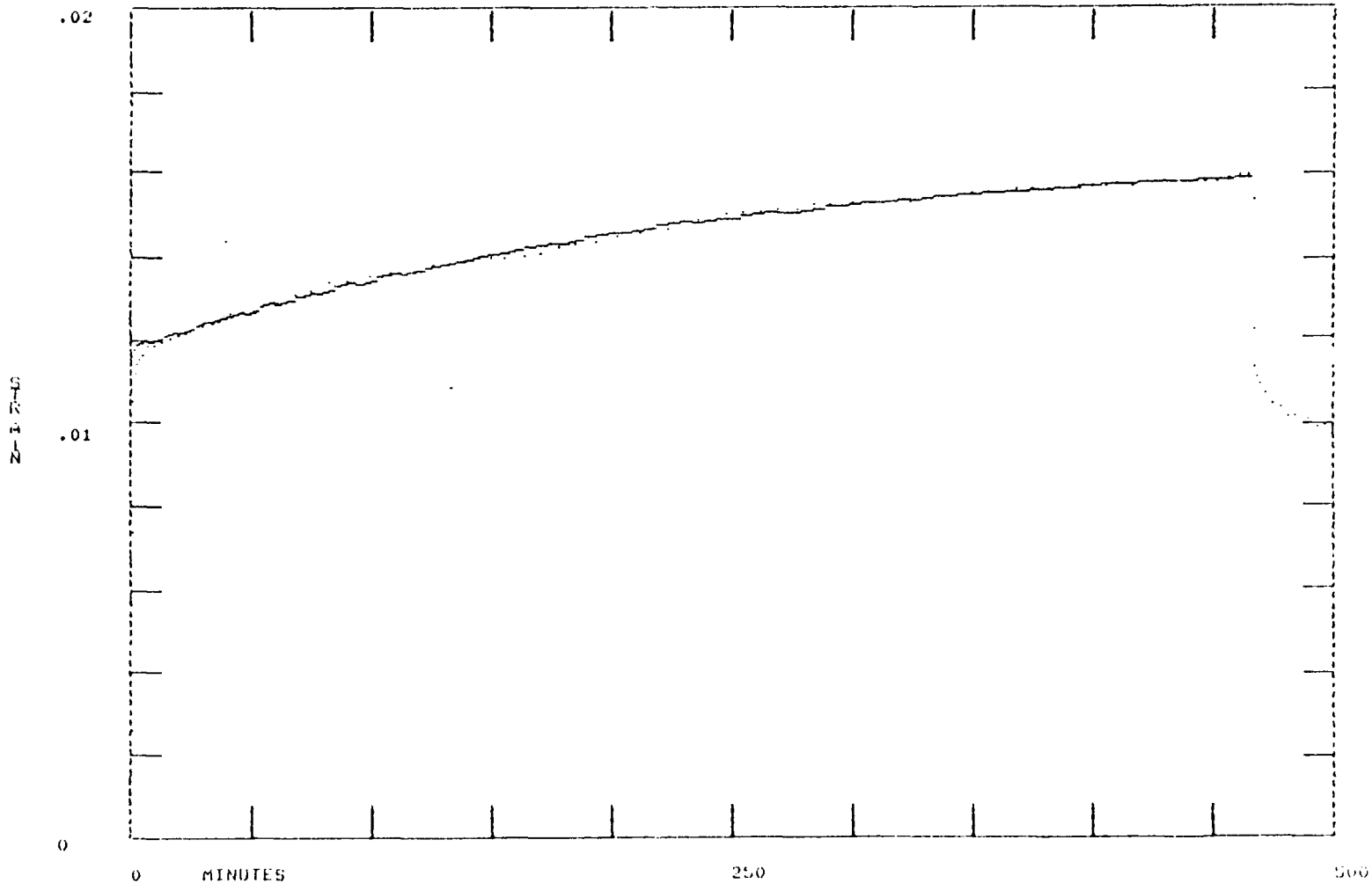
4-PARAMETER SOLID MODEL WITH VALUES OF
A1 = 5.83838E-03, B1 = .19519, A2 = 2.36922E-03, B2 = 4.76226E-03
DELTA TIME = 4
ERROR (USING ALL POINTS): 3.2562%
ERROR (IGNORING FIRST 3 POINTS): 3.1332%

LN-19 T5-T6 11 AUG 75 AREA = 5.0 SQ CM HEIGHT = 2.24 CM
DOTTED LINE: ORIGINAL DATA HEAVY LINE: MODEL PREDICTION



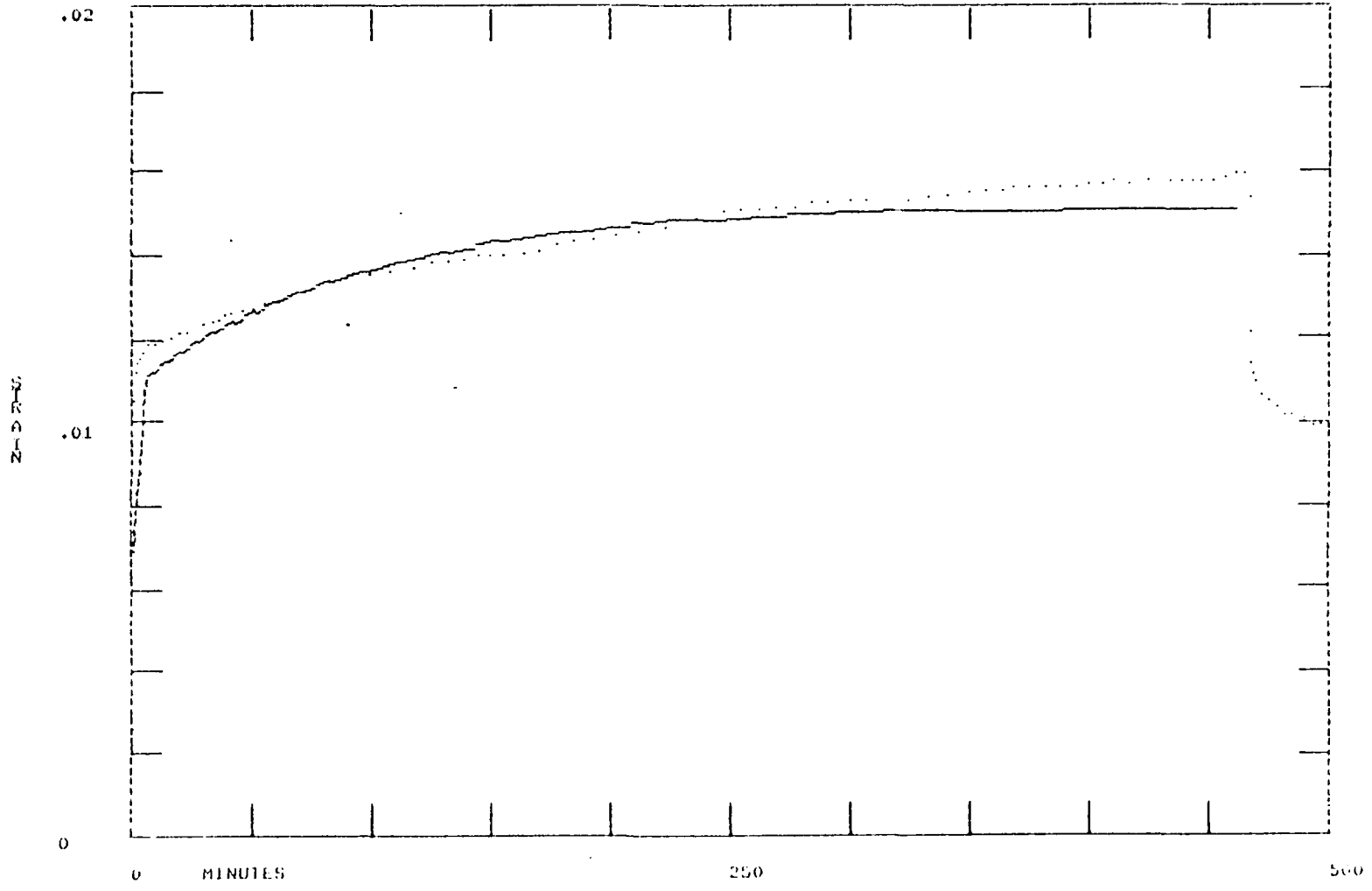
2-PARAMETER SOLID MODEL WITH VALUES OF
A1 = .015446 B1 = .018154
DELTA TIME = 8
ERROR (USING ALL POINTS): 14.226%
ERROR (IGNORING FIRST 3 POINTS): 11.656%

FR 29 16 17 07 AUG 75 AREA = 6.12 SQ CM HEIGHT = 2.34 CM
DOTTED LINE: ORIGINAL DATA HEAVY LINE: MODEL PREDICTION



3-PARAMETER SOLID MODEL WITH VALUES OF
A1 = .016486, B1 = 4.4602E-03, A2 = .011807
DELTA TIME = 8
ERROR (USING ALL POINTS): -2.8331%
ERROR (IGNORING FIRST 3 POINTS): -1.0455%

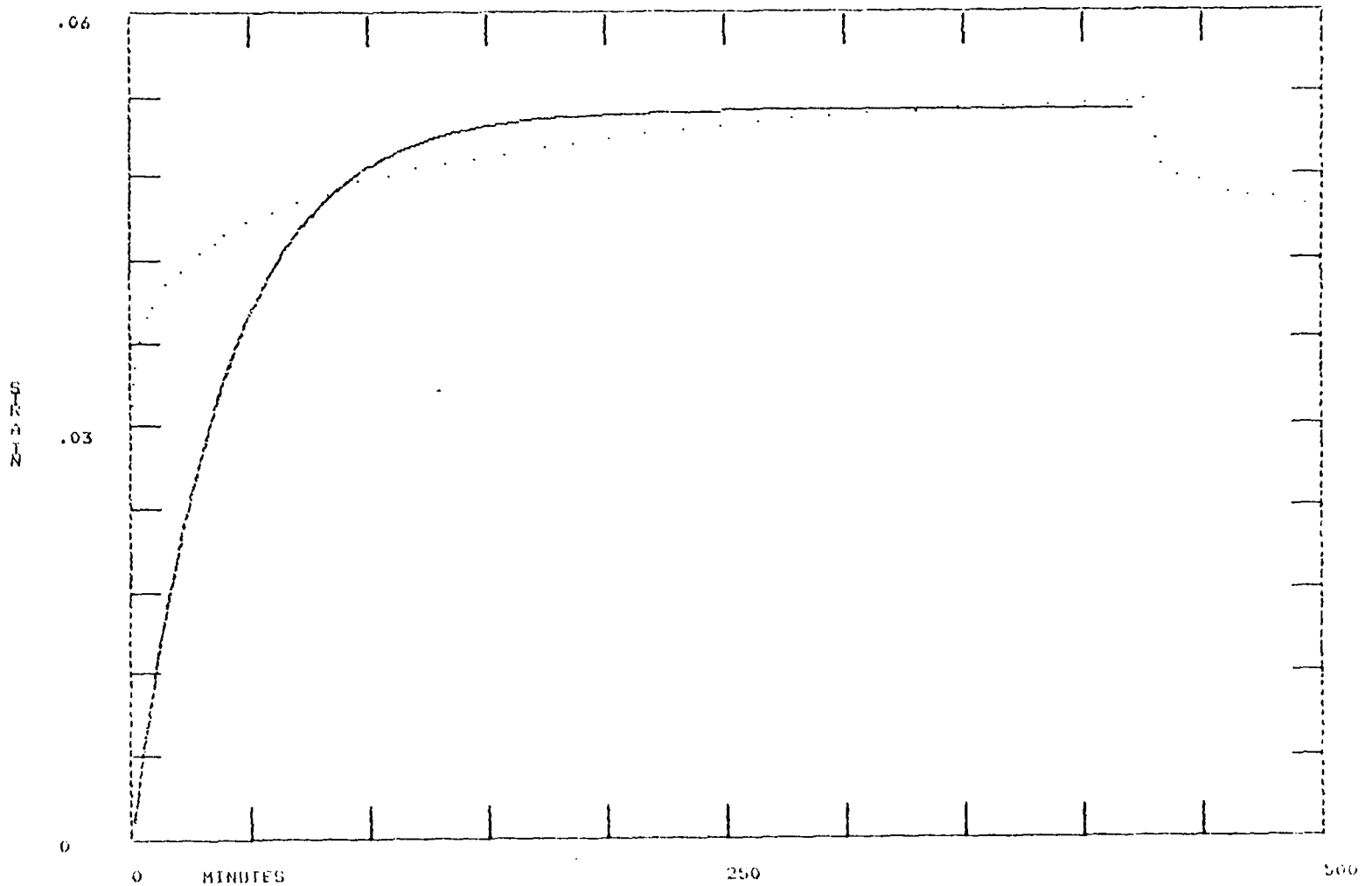
LN-20 16-17 07 AUG 75 AREA = 6.12 50 CM HEIGHT = 2.34 CM
DOTTED LINE: ORIGINAL DATA HEAVY LINE: MODEL PREDICTION



4-PARAMETER SOLID MODEL WITH VALUES OF
A1 = .0103692, B1 = 1.01125, A2 = 4.33217E-03, B2 = .010641
DELTA TIME = 4
ERROR (USING ALL POINTS): 1.8244%
ERROR (IGNORING FIRST 3 POINTS): 2.2552%

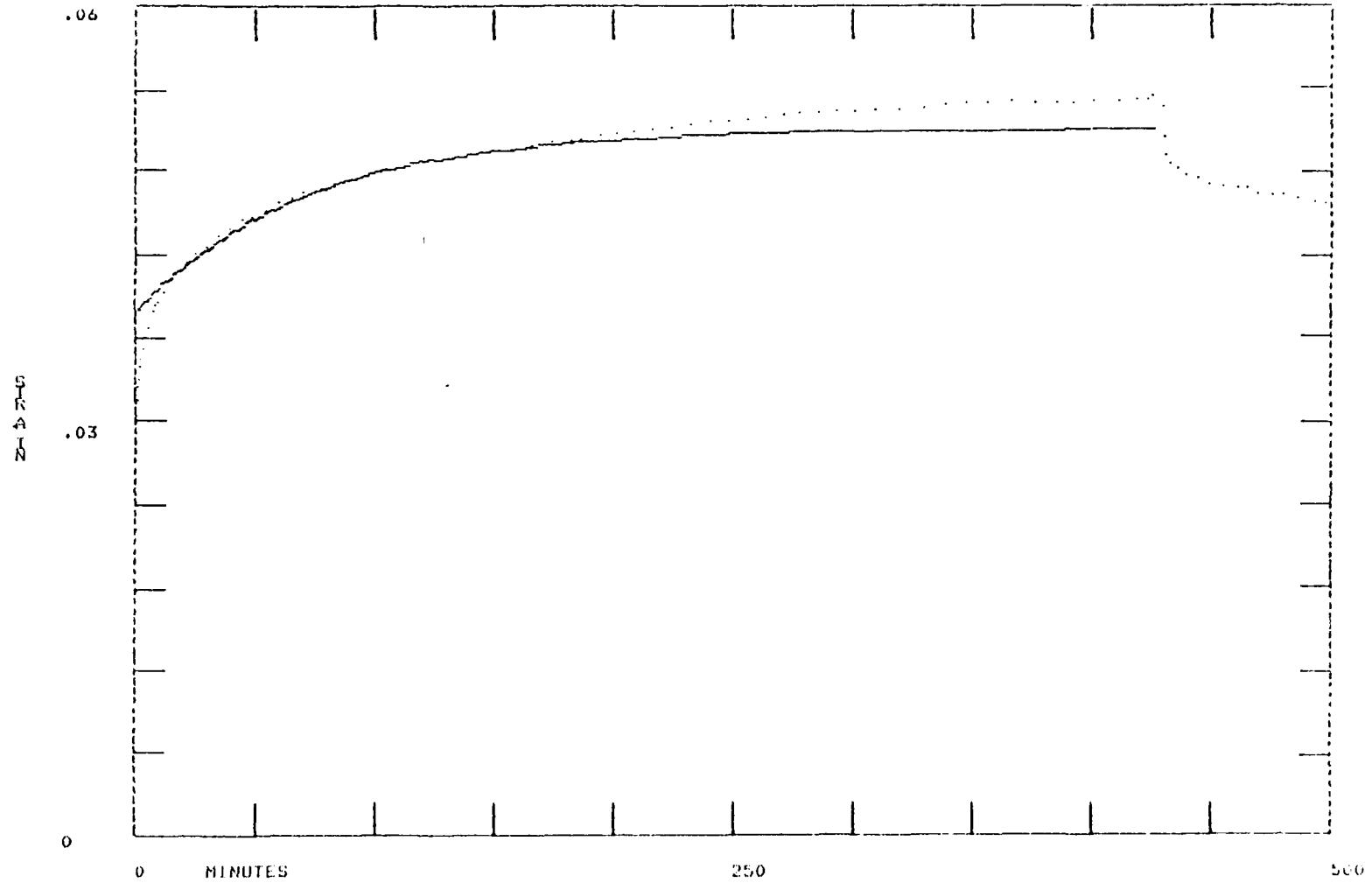
IK-20 16-17 07 AUG 75 AREA = 6.12 SQ CM HEIGHT = 2.34 CM
DOTTED LINE: ORIGINAL DATA HEAVY LINE: MODEL PREDICTION

(1)



2-PARAMETER SOLID MODEL WITH VALUES OF
A1 = .0522087, B1 = .0225643
DELTA TIME = 1.6
ERROR (USING ALL POINTS): 14.3590%
ERROR (IGNORING FIRST 3 POINTS): 10.0590%

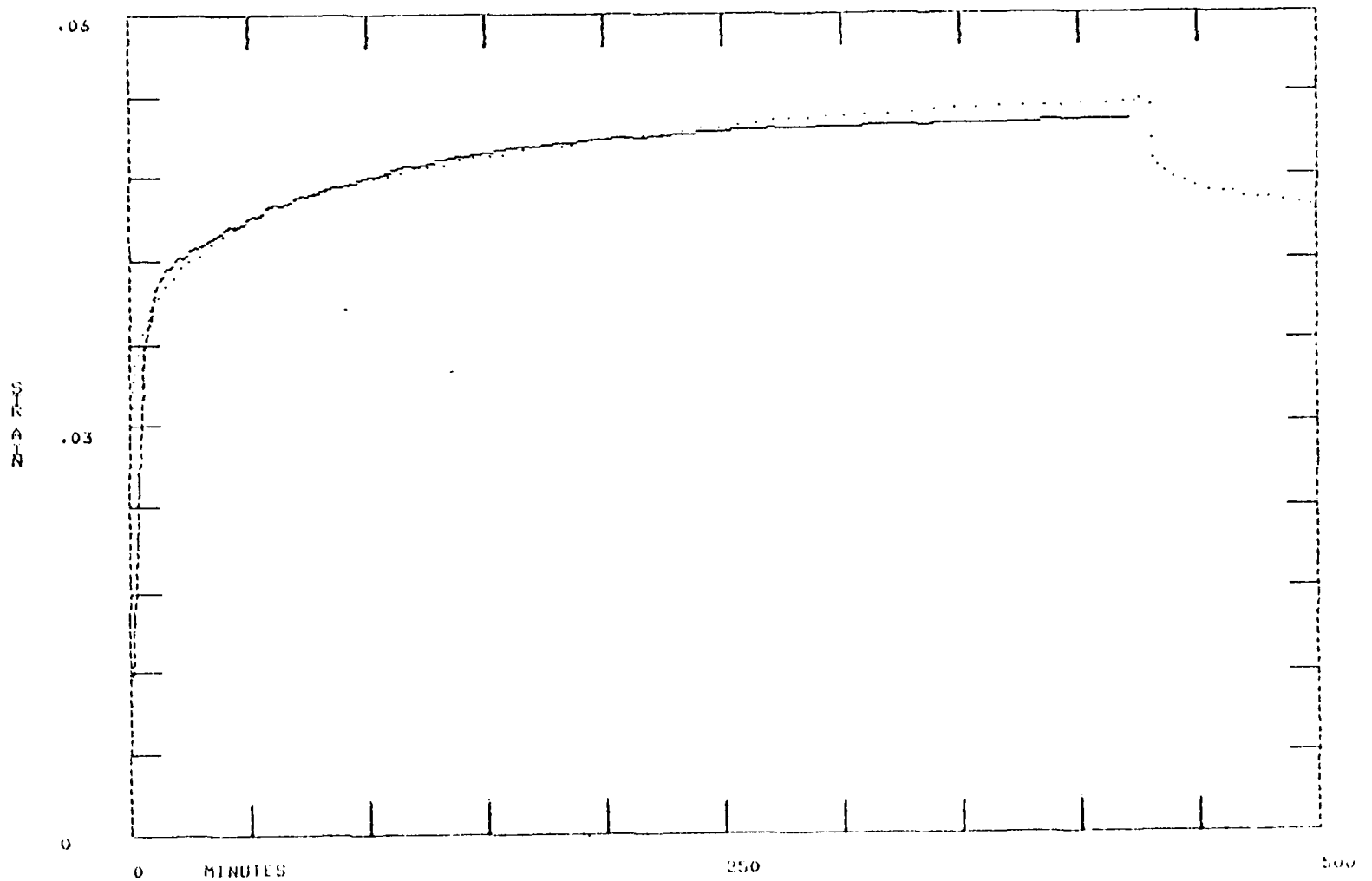
LK-21 T7-18 10 SEP 75 AREA = 0.16 SQ CM HEIGHT = 2.67 CM
DOTTED LINE: ORIGINAL DATA HEAVY LINE: MODEL PREDICTION



3-PARAMETER SOLID MODEL WITH VALUES OF
A1 = .051179, B1 = .013867, A2 = .032977
DELTA TIME = 30
ERROR (USING ALL POINTS): -0.242%
ERROR (IGNORING FIRST 3 POINTS): 0.424%

LN-21 17-18 10 SEP 75 AREA = 8.16 SQ CM HEIGHT = 2.67 CM
DOTTED LINE: ORIGINAL DATA HEAVY LINE: MODEL PREDICTION

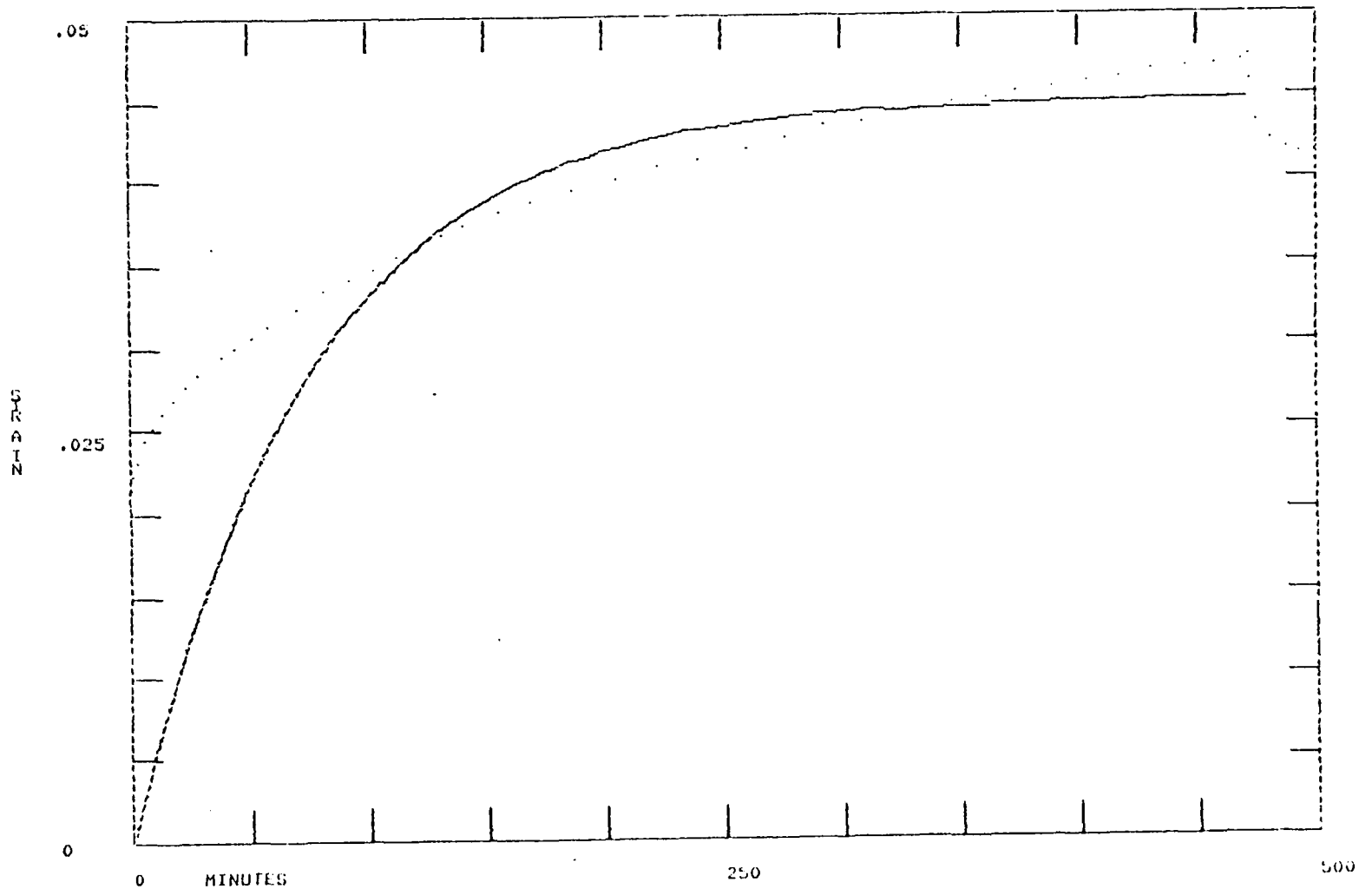
4



4-PARAMETER SOLID MODEL WITH VALUES OF
A1 = .039829, B1 = .343924, A2 = .012447, B2 = .010828

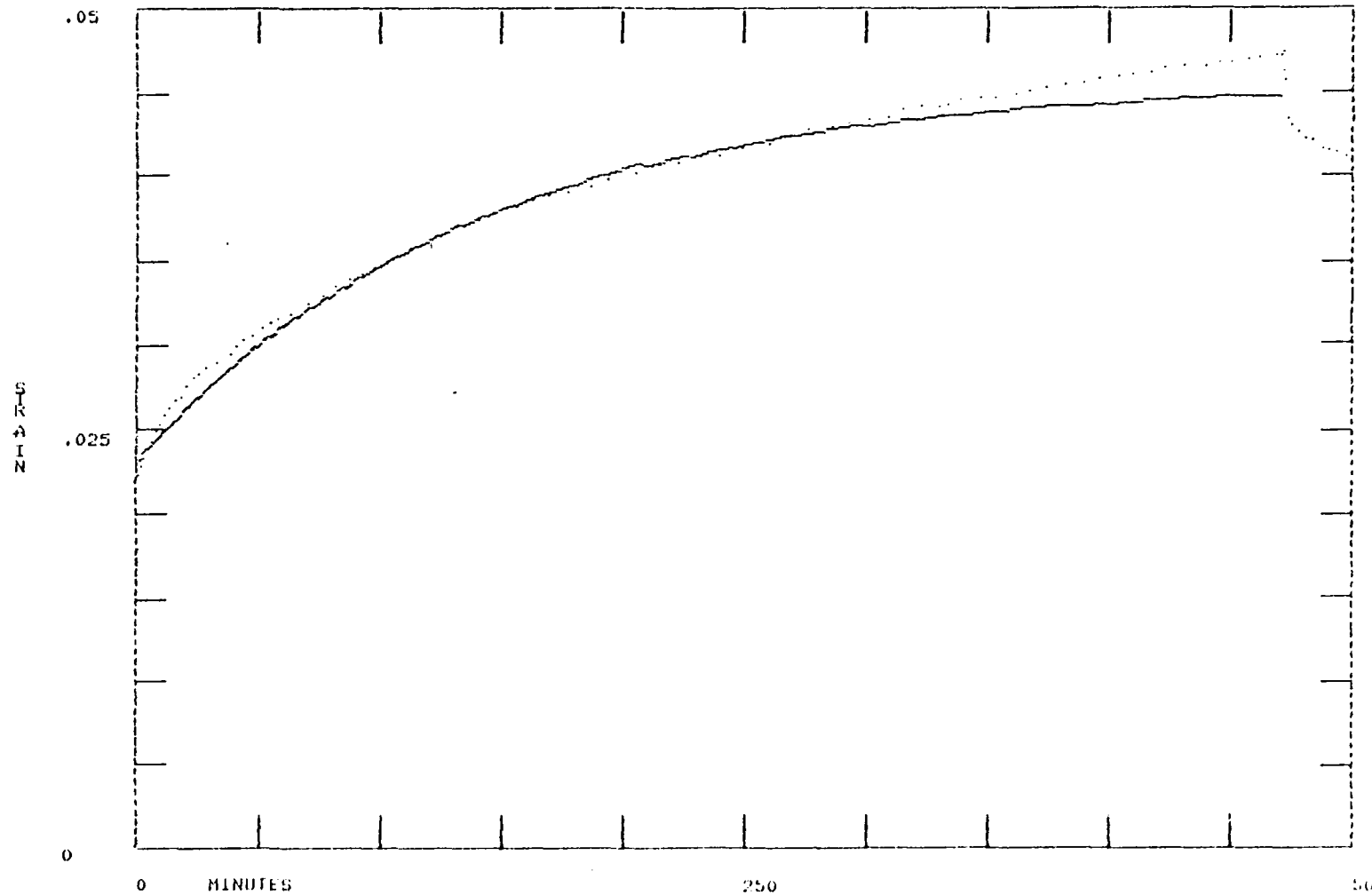
DELTA TIME = 4
ERROR (USING ALL POINTS): 3.6492%
ERROR (IGNORING FIRST 3 POINTS): 3.0522%

EX-21 17 18 10 SEP 75 AREA = 0.16 SQ CM HEIGHT = 2.67 CM
DOTTED LINE: ORIGINAL DATA HEAVY LINE: MODEL PREDICTION



2-PARAMETER SOLID MODEL WITH VALUES OF
AL = .044945, BL = .013395
DELTA TIME = 30
ERROR (USING ALL POINTS): 13.120%
ERROR (IGNORING FIRST 3 POINTS): 10.217%

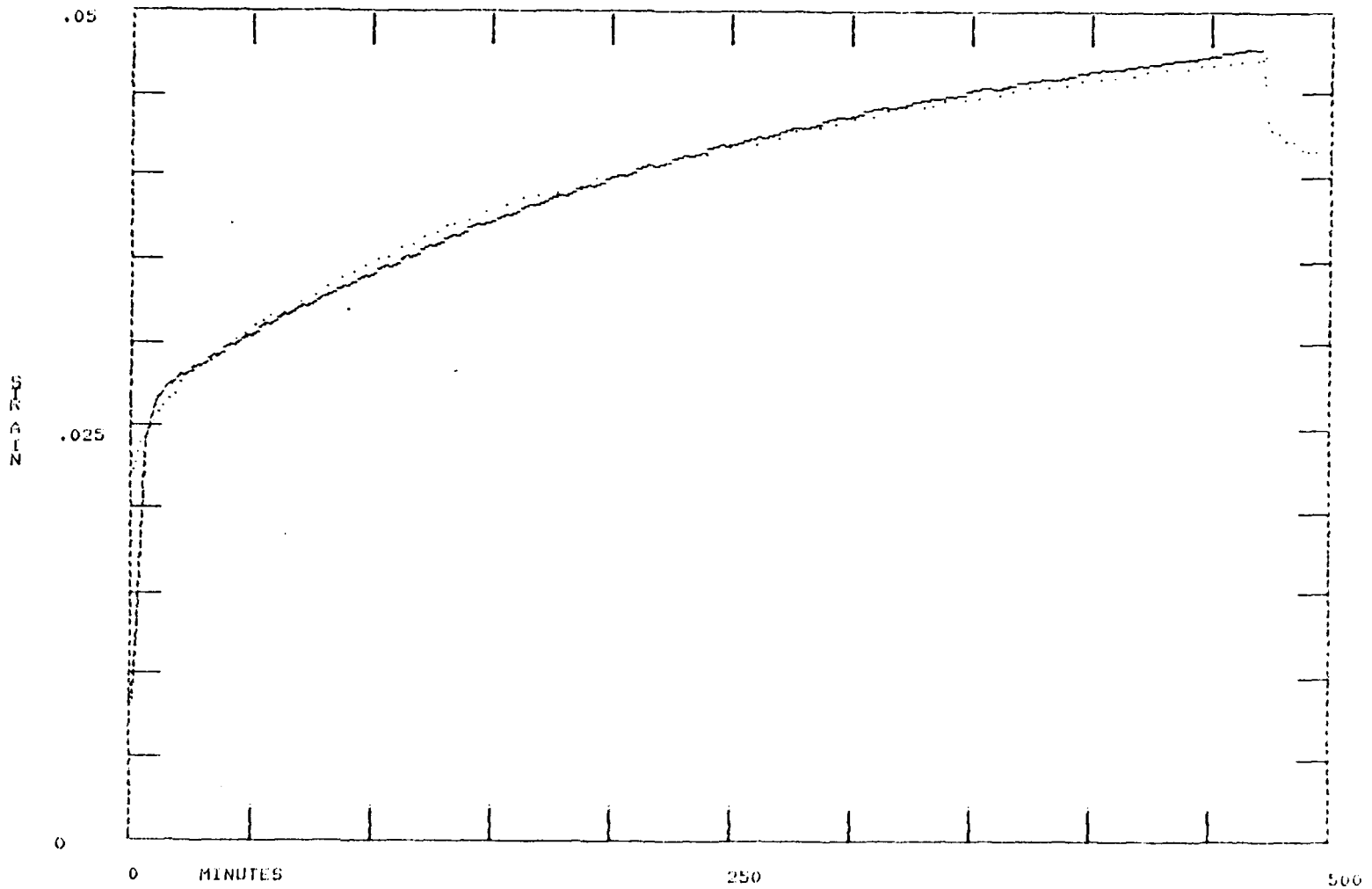
LR-22 TB-19 16 JUN 75 AREA = 8.03 SQ CM HEIGHT = 2.615 CM
DOTTED LINE: ORIGINAL DATA HEAVY LINE: MODEL PREDICTION



3-PARAMETER SOLID MODEL WITH VALUES OF
A1 = .0457955, E1 = 7.1614E-03, A2 = .0228252
DELTA TIME = 4
ERROR (USING ALL POINTS): 1.18%
ERROR (IGNORING FIRST 3 POINTS): 1.27%

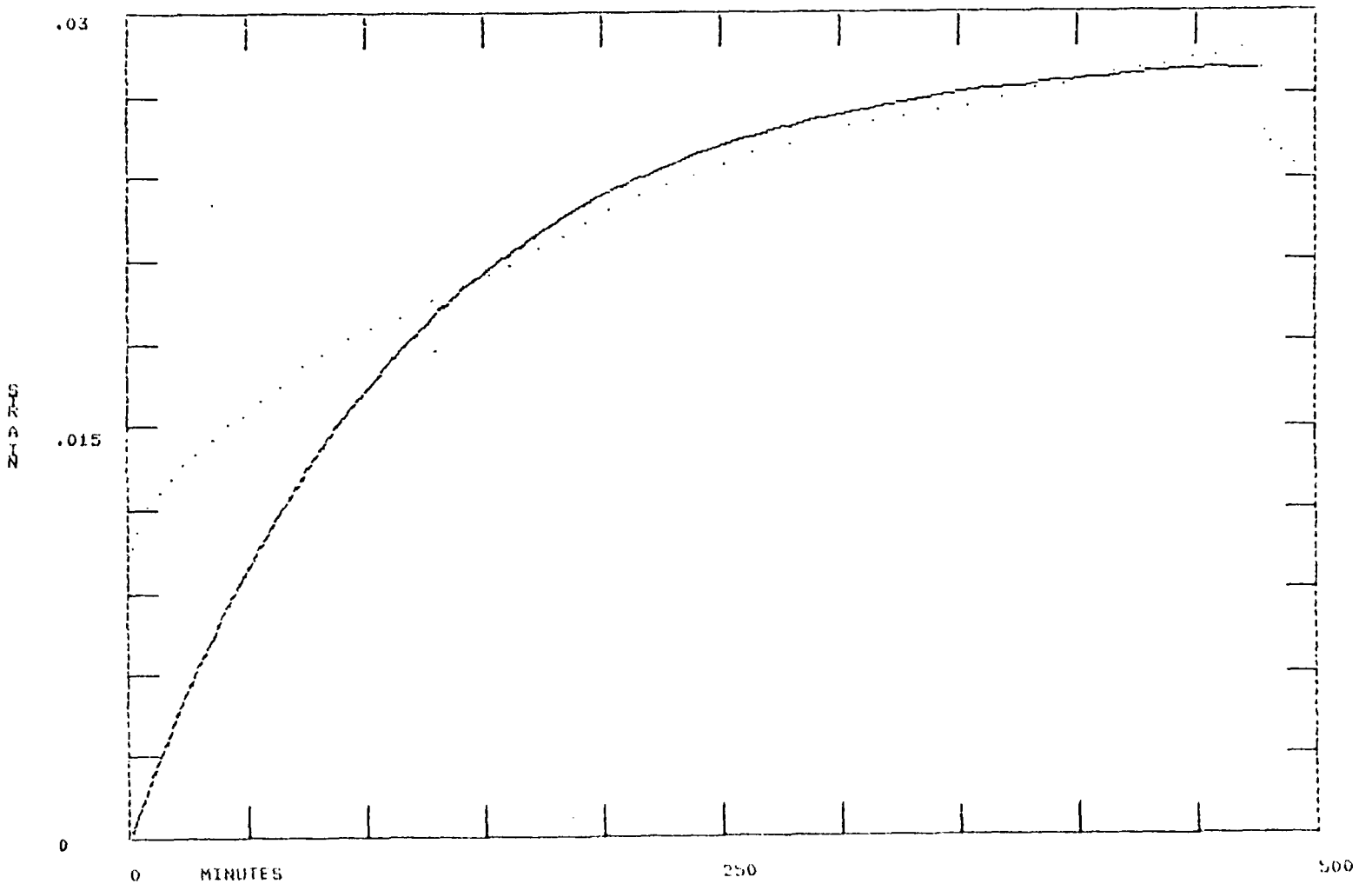
IN-22 TO T9 16 JUN 75 AREA = 0.03 SQ CM HEIGHT = 2.615 CM
DOTTED LINE: ORIGINAL DATA HEAVY LINE: MODEL PREDICTION

47



4-PARAMETER SOLID MODEL WITH VALUES OF
A1 = .022612, M1 = .4031, A2 = .022504, M2 = 3.6708E-03
DELTA TIME = 4
ERROR (USING ALL POINTS): 1.224%
ERROR (IGNORING FIRST 3 POINTS): 0.569%

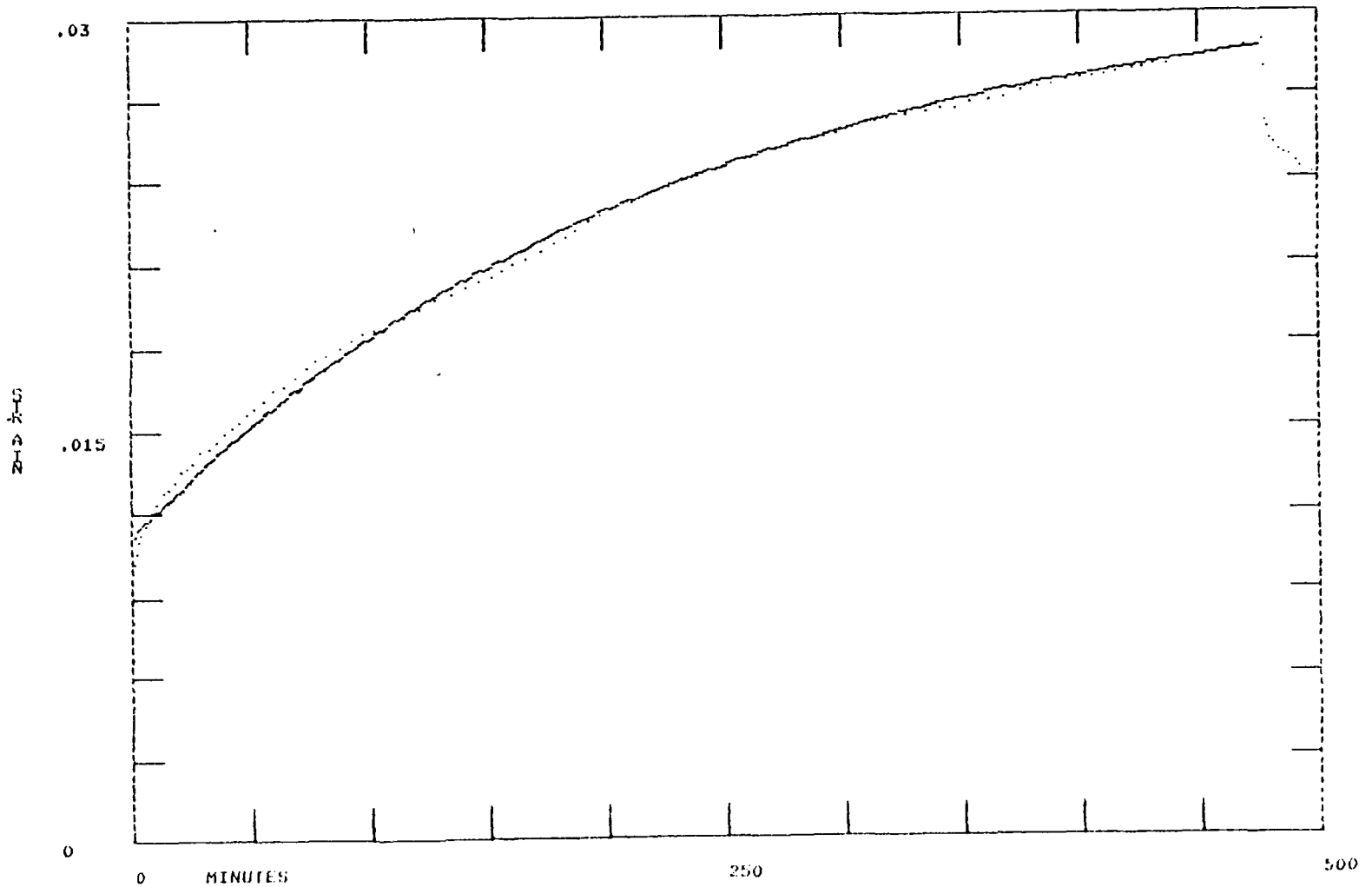
LK-22 T8-T9 16 JUN 75 AREA = 0.03 SQ CM HEIGHT = 2.615 CM
DOTTED LINE: ORIGINAL DATA HEAVY LINE: MODEL PREDICTION



2-PARAMETER SOLID MODEL WITH VALUES OF
A1 = .022357, B1 = .0085228
DELTA TIME = 8
ERROR (USING ALL POINTS): 11.122%
ERROR (IGNORING FIRST 3 POINTS): 9.222%

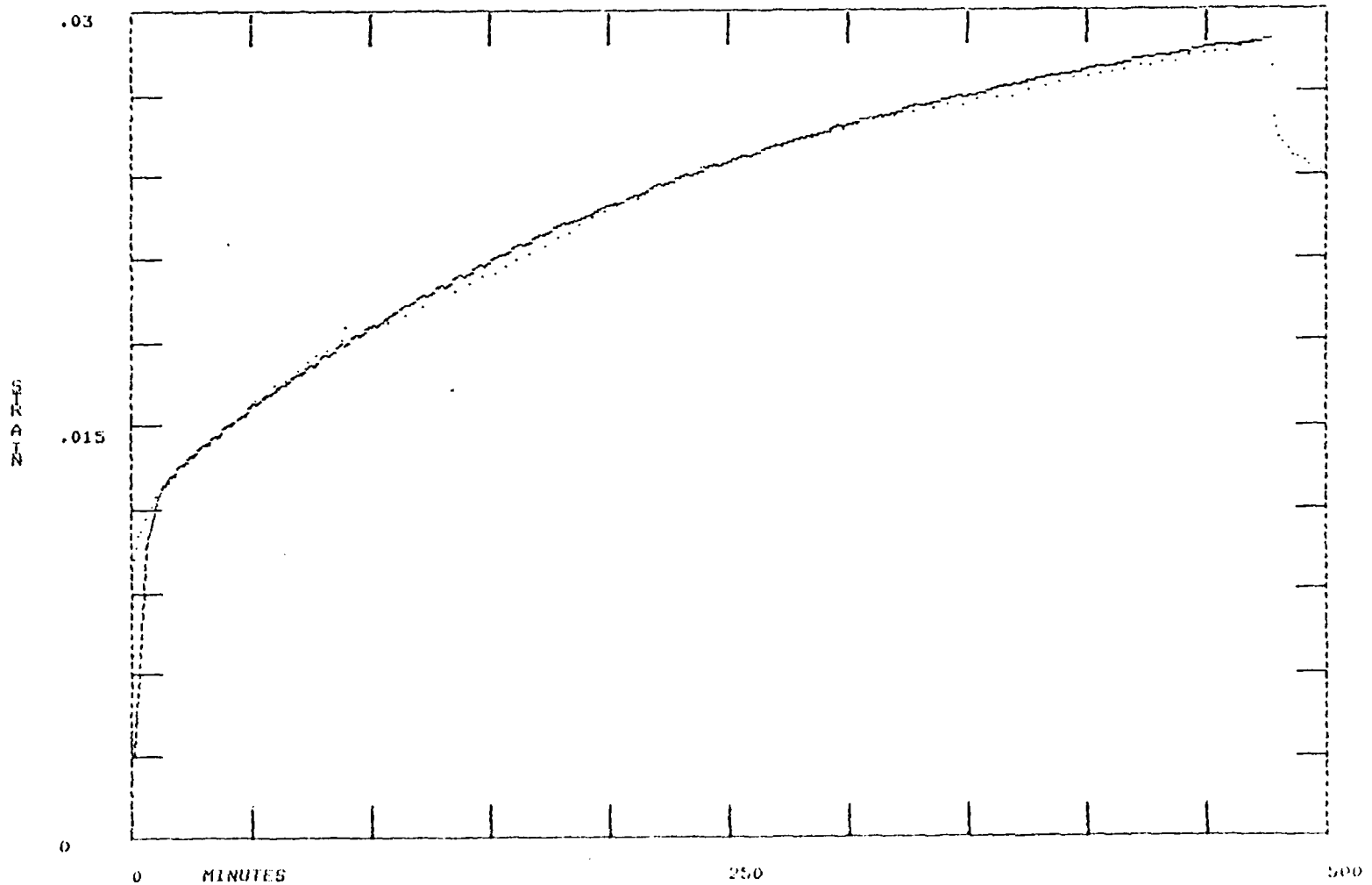
LN-23 T9-T10 06 AUG 75 AREA = 9.12 SQ CM HEIGHT = 2.67 CM
DOTTED LINE: ORIGINAL DATA HEAVY LINE: MODEL PREDICTION

11



3-PARAMETER SOLID MODEL WITH VALUES OF
A1 = .031229, B1 = 4.3816E-03, A2 = .011263
DELTA TIME = 4
ERROR (USING ALL POINTS): -0.6228%
ERROR (IGNORING FIRST 3 POINTS): -0.0224%

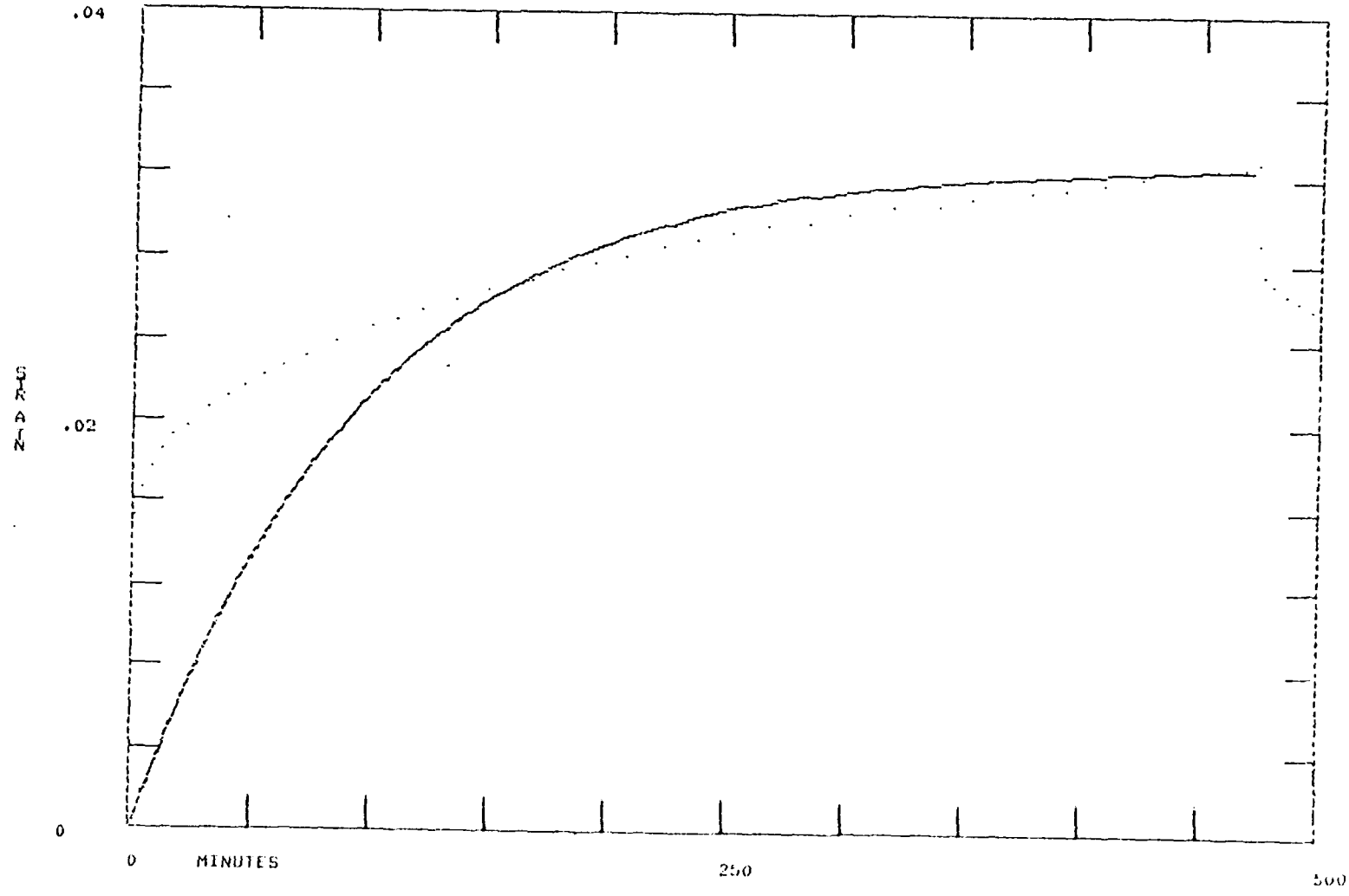
LK-23 T9-T10 06 AUG 75 AREA = 9.12 SQ CM HEIGHT = 2.67 CM
DOTTED LINE: ORIGINAL DATA HEAVY LINE: MODEL PREDICTION



4-PARAMETER SOLID MODEL WITH VALUES OF
A1 = .012212, E1 = .229229, A2 = .019952, B2 = 3.9082E-03
DELTA TIME = 4
ERROR (USING ALL POINTS): 0.904%
ERROR (IGNORING FIRST 35 POINTS): 0.589%

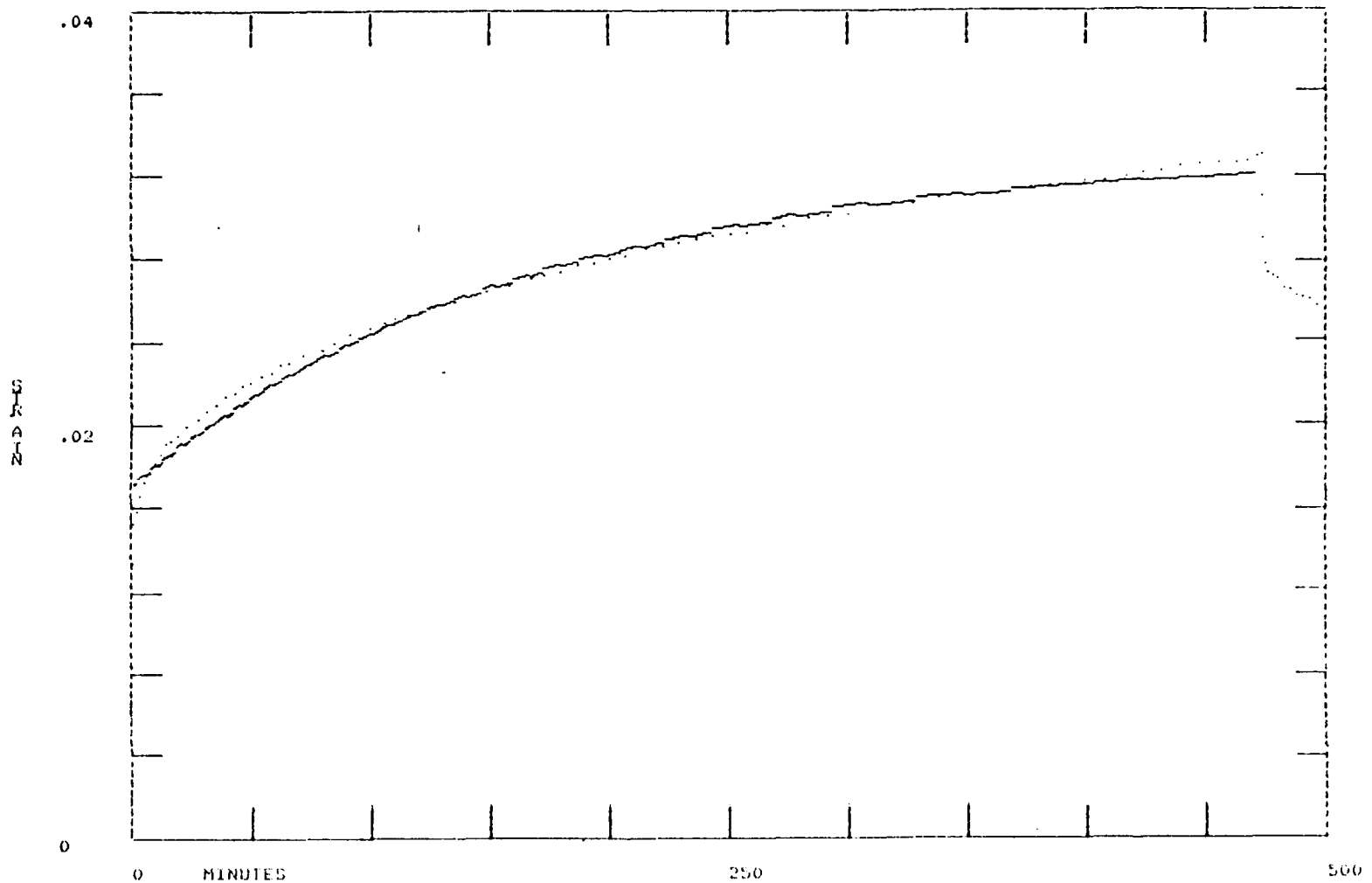
LA-23 19-110 06 AUG 75 AREA = 9.12 SQ CM HEIGHT = 2.67 CM
DOTTED LINE: ORIGINAL DATA HEAVY LINE: MODEL PREDICTION

C1



2-PARAMETER SOLID MODEL WITH VALUES OF
AL = .0322761, BL = .010566
DELTA TIME = 8
ERROR (USING ALL POINTS): 14.2622%
ERROR (IGNORING FIRST 3 POINTS): 11.0220%

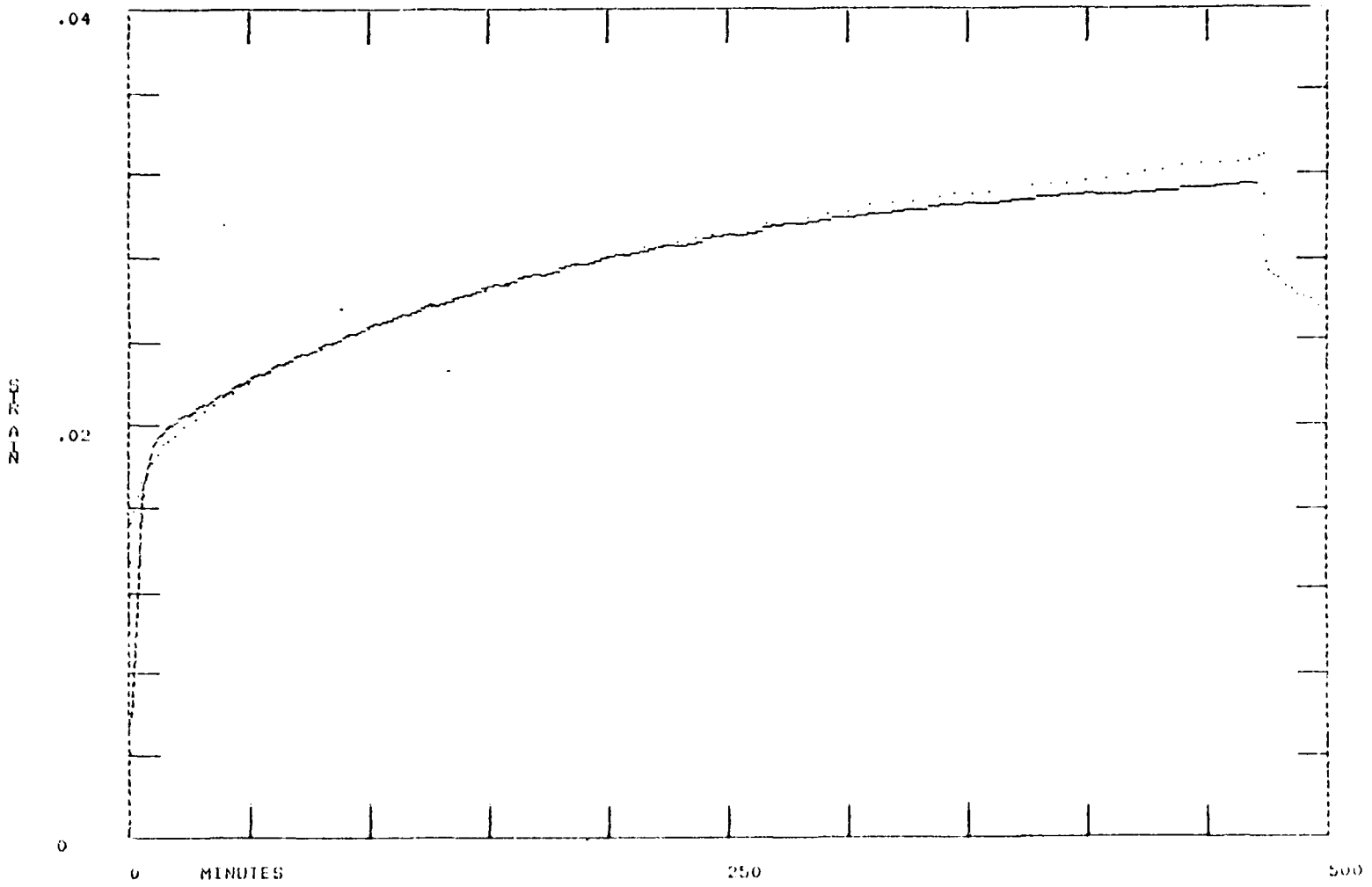
LK-24 T10-T11 18 JUN 75 AREA = 10.33 SQ CM HEIGHT = 2.795 CM
DOTTED LINE: ORIGINAL DATA HEAVY LINE: MODEL PREDICTION



3-PARAMETER SOLID MODEL WITH VALUES OF
A1 = .0335, B1 = 6.1208E-03, A2 = .01718

DELTA TIME = 4
ERROR (USING ALL POINTS): -0.202%
ERROR (IGNORING FIRST 3 POINTS): 0.432%

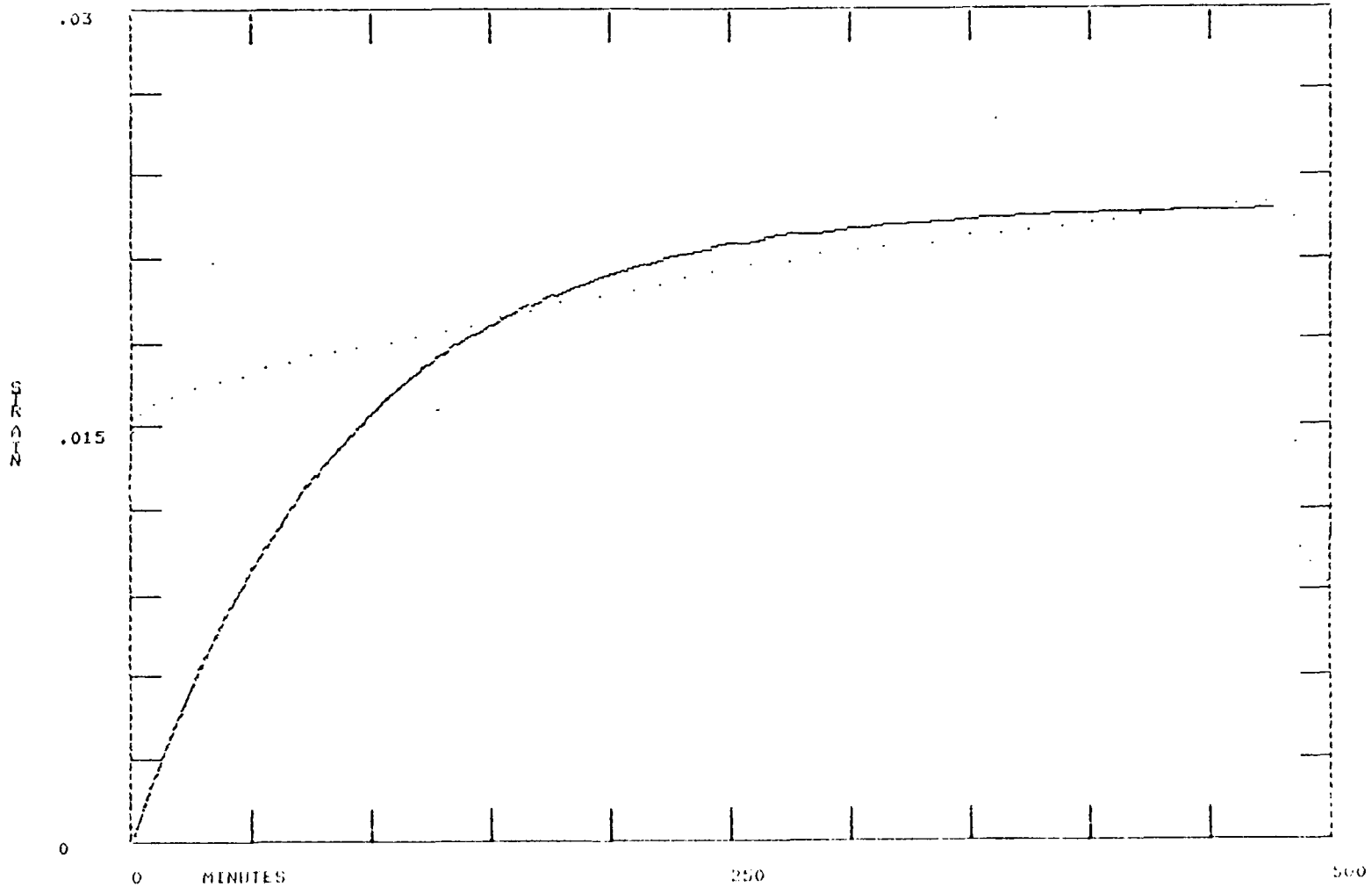
LK-24 T10-T11 18 JUN 75 AREA = 10.33 SQ CM HEIGHT = 2.795 CM
DOTTED LINE: ORIGINAL DATA HEAVY LINE: MODEL PREDICTION



4-PARAMETER SOLID MODEL WITH VALUES OF
A1 = .013855, B1 = .356728, A12 = .013562, B12 = 5.59561E-03

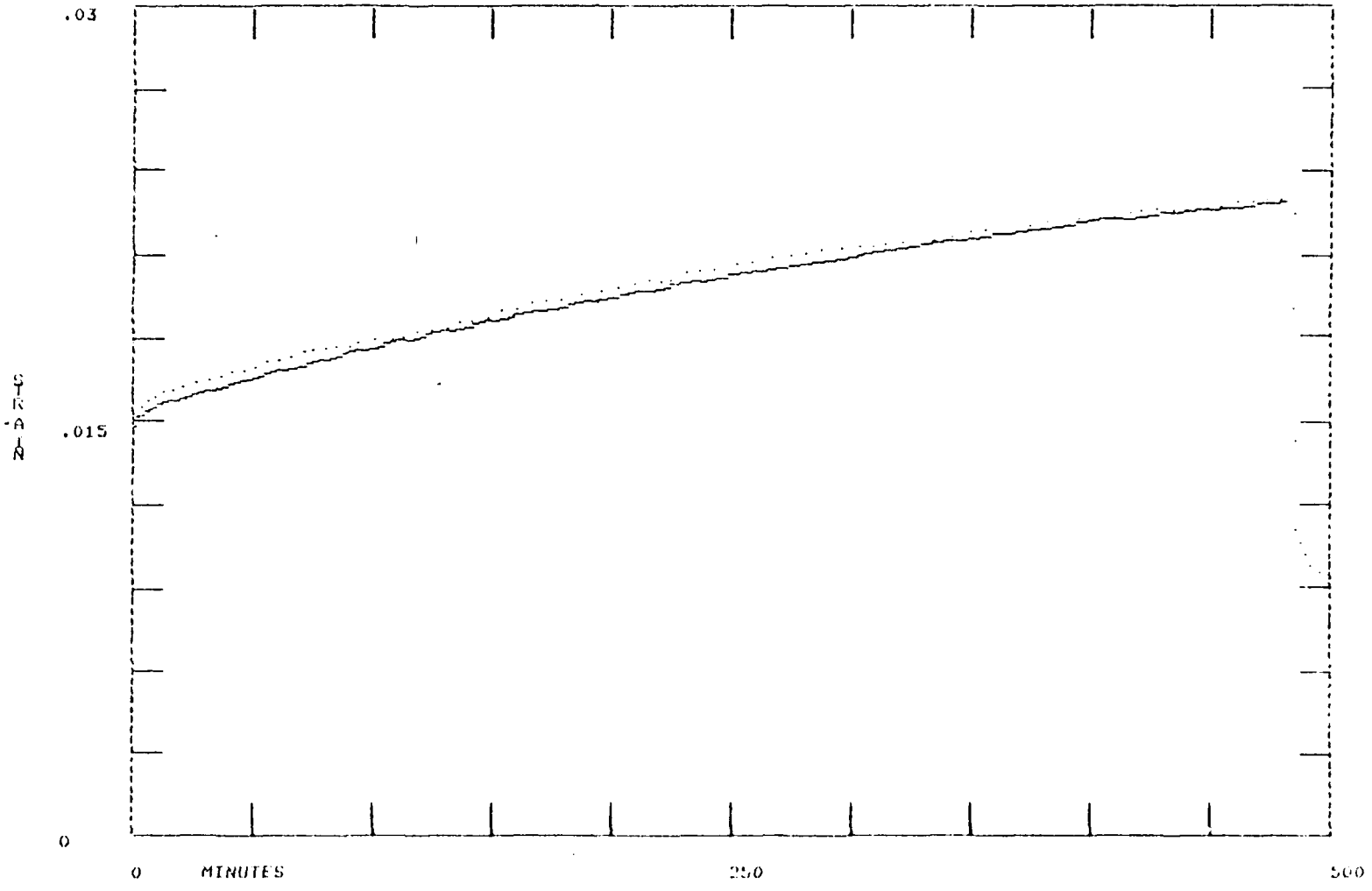
DELTA TIME = 4
ERROR (USING ALL POINTS): 2.068%
ERROR (IGNORING FIRST 3 POINTS): 1.359%

LK 24 T10-T11 18 JUN 75 AREA = 10.33 SQ CM HEIGHT = 2.795 CM
DOTTED LINE: ORIGINAL DATA HEAVY LINE: MODEL PREDICTION



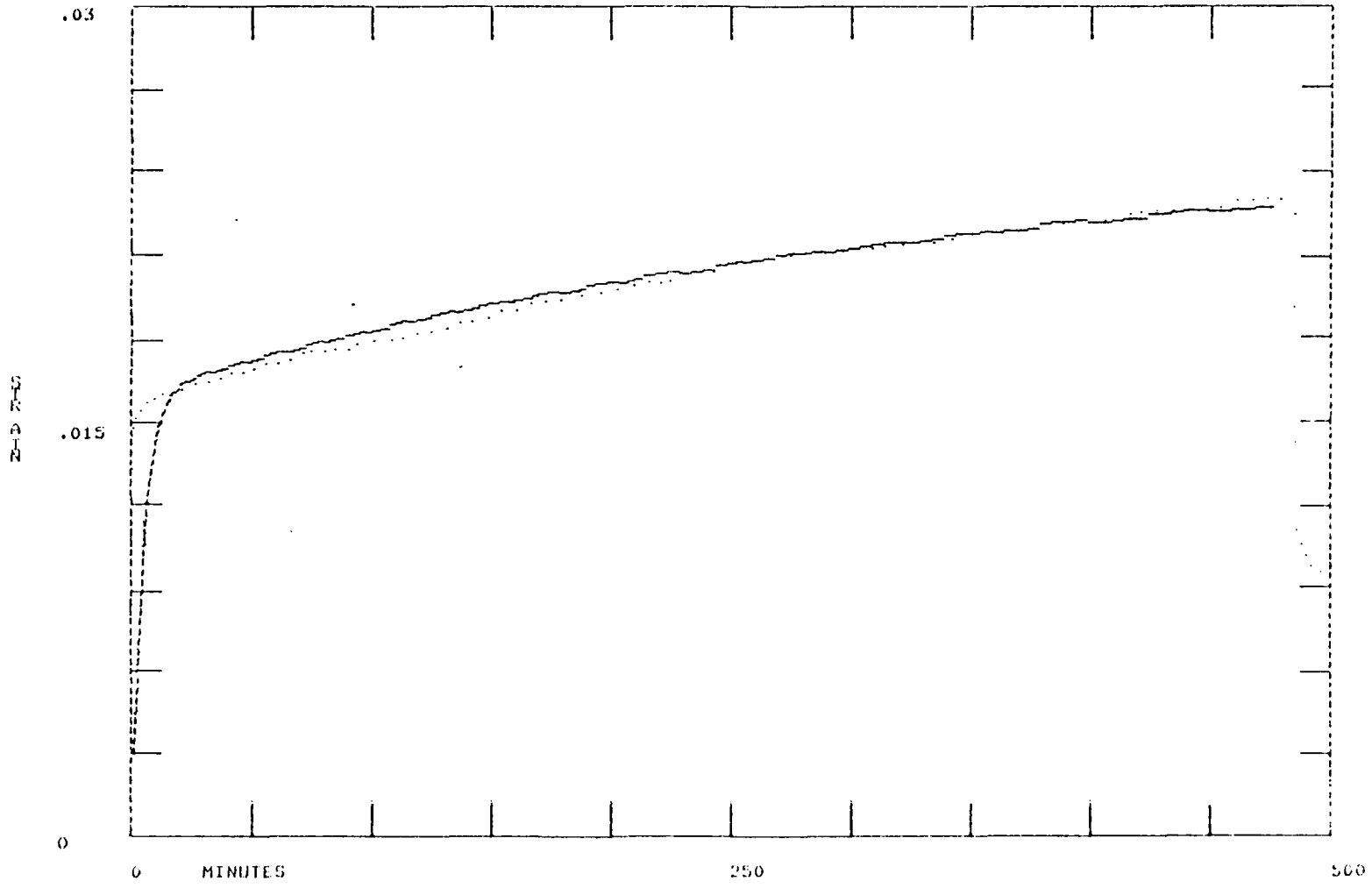
2-PARAMETER SOLID MODEL WITH VALUES OF
A1 = .0222851 , B1 = .011312
DELTA TIME = 30
ERROR (USING ALL POINTS): 12.59%
ERROR (IGNORING FIRST 3 POINTS): 8.25%

LN-25 TU-112 19 JUN 75 AREA = 17.8 SQ CM HEIGHT = 3.515 CM
DOTTED LINE: ORIGINAL DATA HEAVY LINE: MODEL PREDICTION



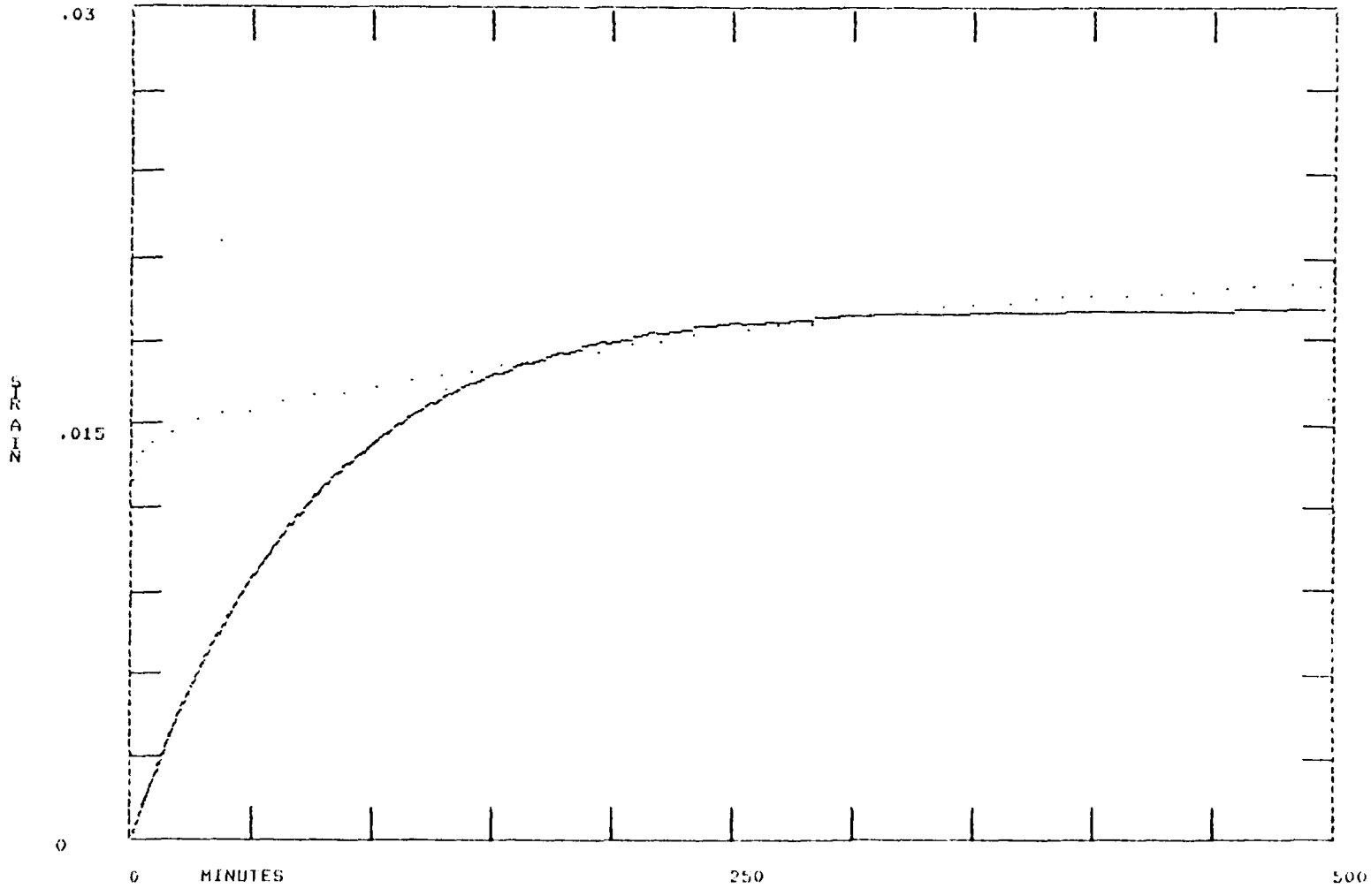
3-PARAMETER SOLID MODEL WITH VALUES OF
A1 = .0226515, B1 = 2.35138E-03, A2 = .0153518
DELTA TIME = 4
ERROR (USING ALL POINTS): 0.2465%
ERROR (IGNORING FIRST 3 POINTS): 0.989%

LX-25 T11-T12 19 JUN 75 AREA = 11.856 CM HEIGHT = 3.515 CM
DOTTED LINE: ORIGINAL DATA HEAVY LINE: MODEL PREDICTION



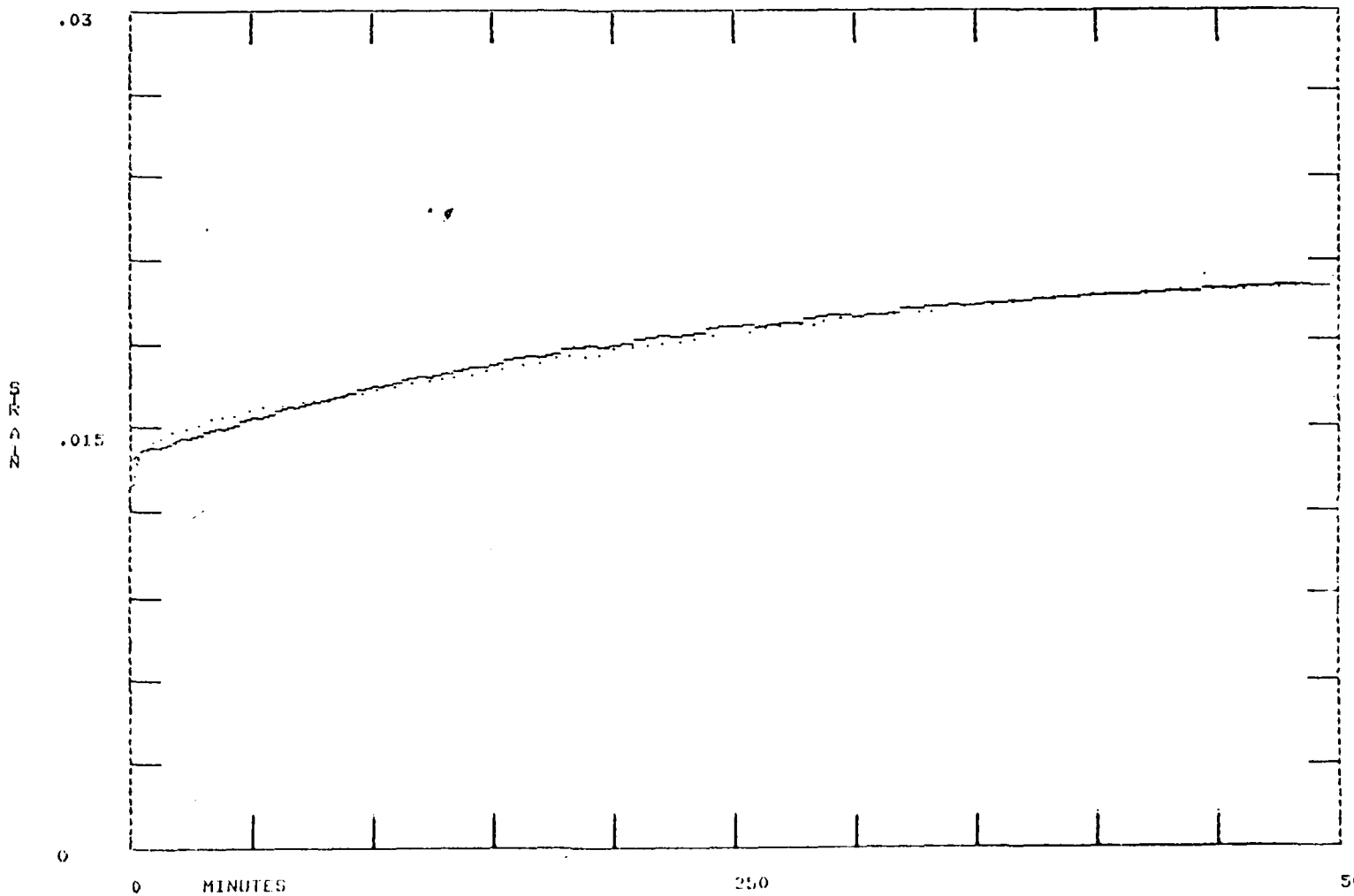
4-PARAMETER SOLID MODEL WITH VALUES OF
A1 = .016016, B1 = .22218, A2 = 8.82228E-03, B2 = 3.07332E-03
DELTA TIME = 4
ERROR (USING ALL POINTS): 2.119%
ERROR (IGNORING FIRST 3 POINTS): 1.225%

LK-25 T11-T12 19 JUN 75 AREA = 11.8 50 CM HEIGHT = 3.515 CM
DOTTED LINE: ORIGINAL DATA HEAVY LINE: MODEL PREDICTION



2-PARAMETER SOLID MODEL WITH VALUES OF
A1 = .019236, X1 = .013725
DELTA TIME = 16
ERROR (USING ALL POINTS): 15.239%
ERROR (IGNORING FIRST 3 POINTS): 11.515%

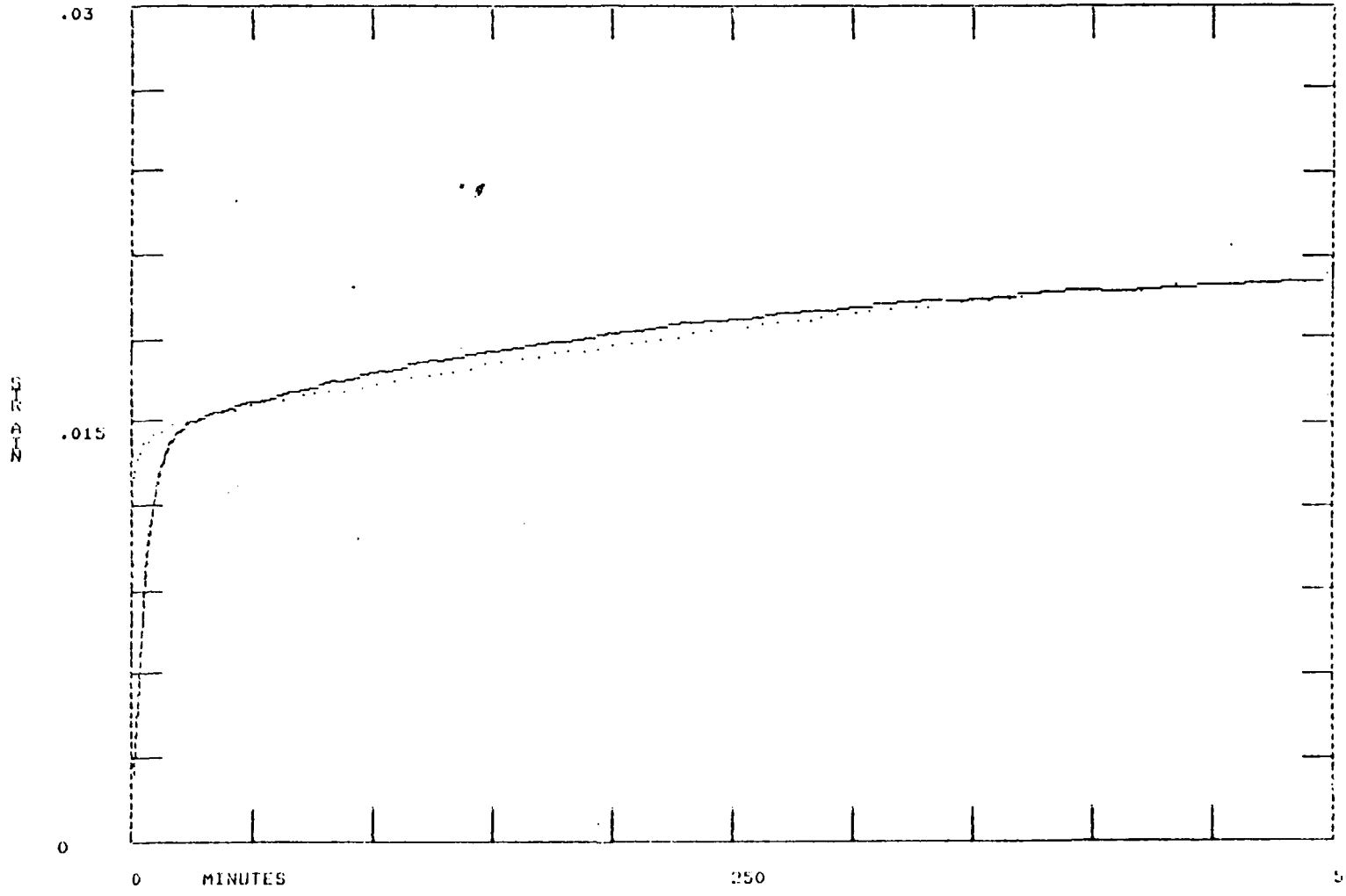
LN-26 T12-L1 01 AUG 75 AREA = 11.18 SQ CM HEIGHT = 3.725 CM
DOTTED LINE: ORIGINAL DATA HEAVY LINE: MODEL PREDICTION



3-PARAMETER SOLID MODEL WITH VALUES OF
A1 = .02097, B1 = 4.25534E-03, A2 = .014062
DELTA TIME = 4
ERROR (USING ALL POINTS): -1.2662%
ERROR (IGNORING FIRST 3 POINTS): -0.3782%

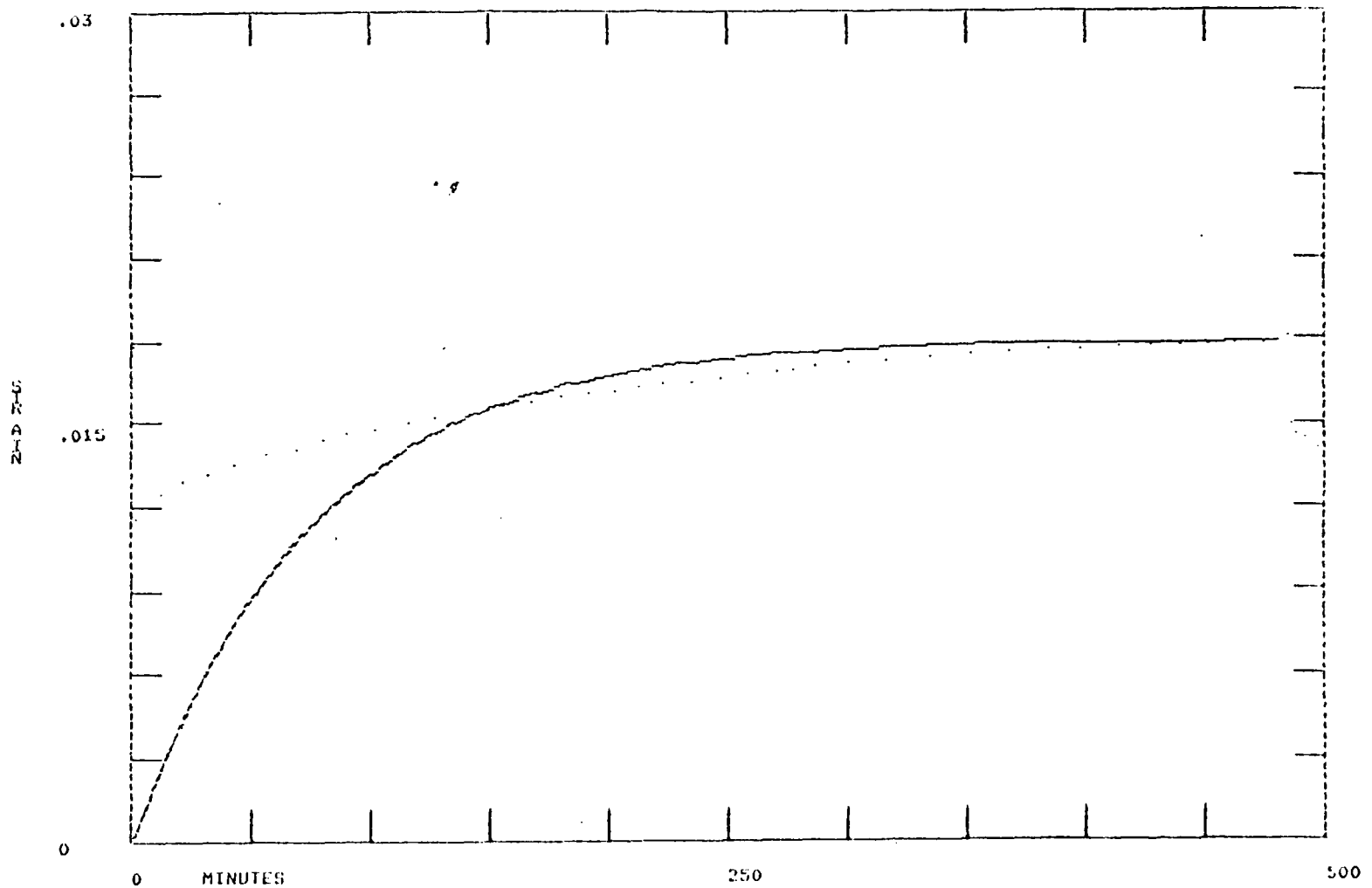
LK-26 113-11 01 AUG 75 AREA = 11.18 SQ CM HEIGHT = 3.725 CM
DOTTED LINE: ORIGINAL DATA HEAVY LINE: MODEL PREDICTION

51



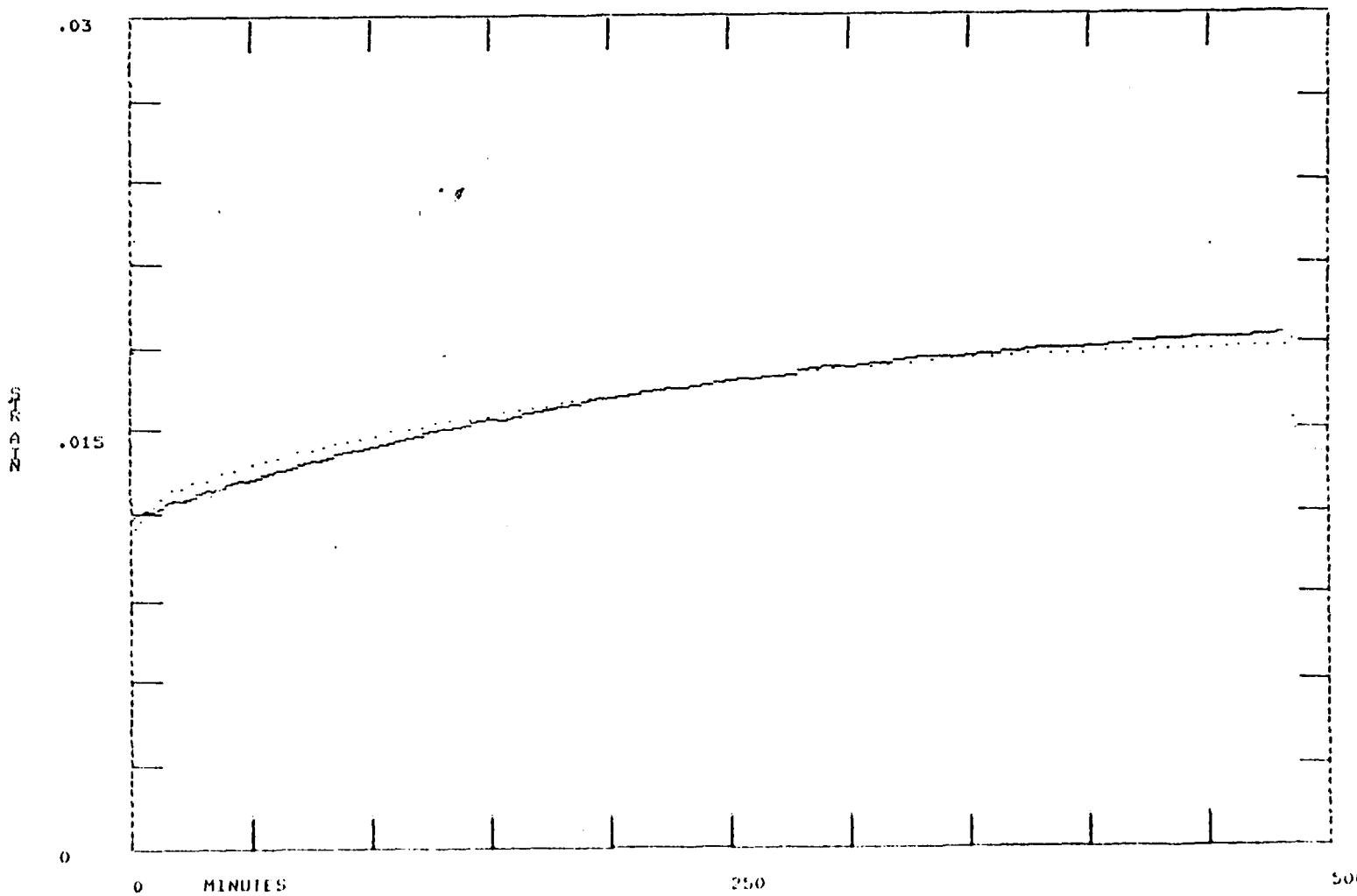
4-PARAMETER SOLID MODEL WITH VALUES OF
A1 = .014512, X1 = .20104, A2 = 6.27341E-03, X2 = 4.4478E-03
DELTA TIME = 8
ERROR (USING ALL POINTS): 2.851%
ERROR (IGNORING FIRST 3 POINTS): 2.056%

LN-26 T12-11 01 AUG 75 AREA = 11.18 SQ CM HEIGHT = 3.725 CM
DOTTED LINE: ORIGINAL DATA HEAVY LINE: MODEL PREDICTION



2-PARAMETER SOLID MODEL WITH VALUES OF
A1 = .018043 , B1 = .013421
DELTA TIME = 16
ERROR (USING ALL POINTS) : 11.939%
ERROR (IGNORING FIRST 3 POINTS) : 7.3888%

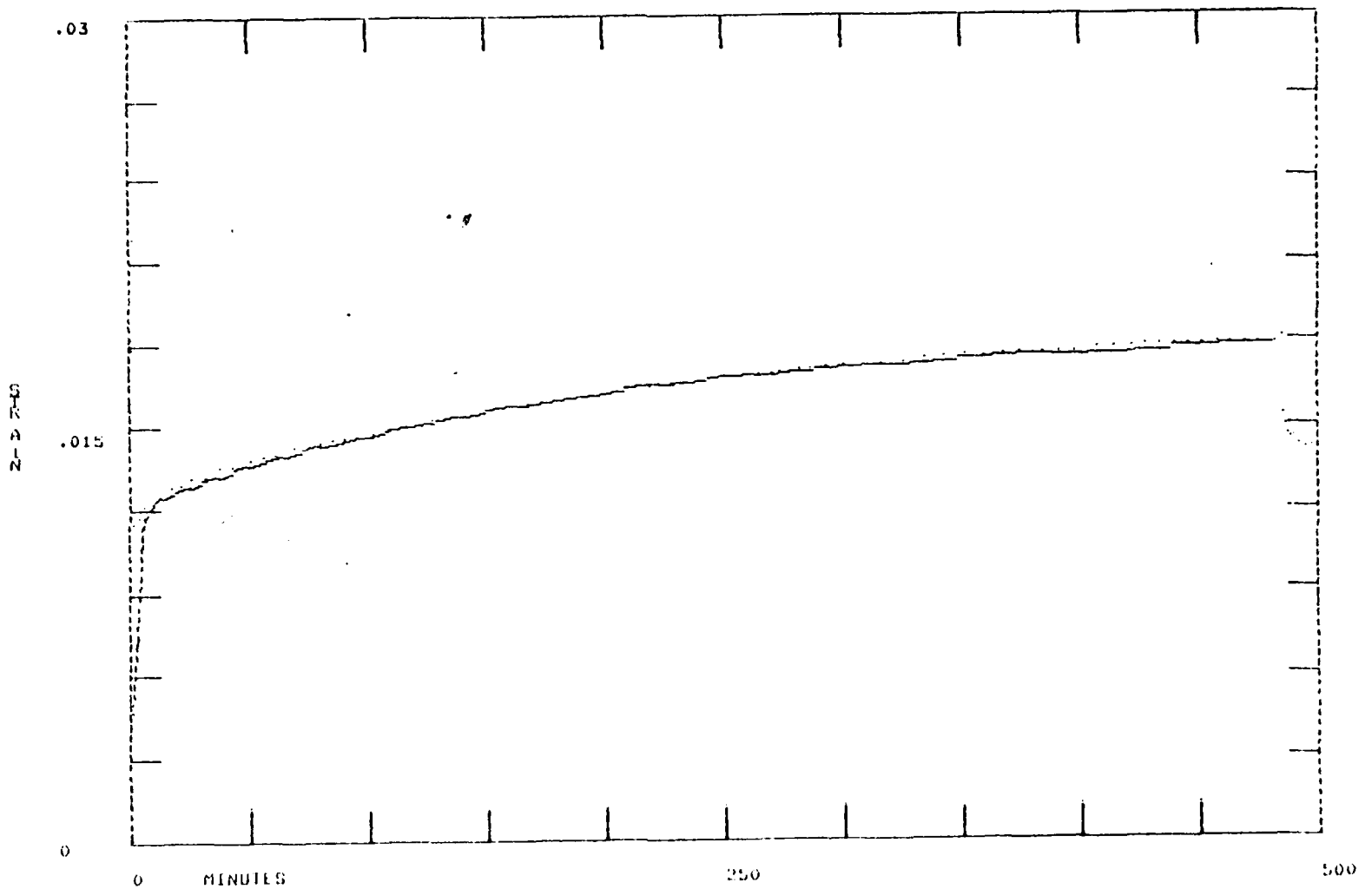
LN-27 L1-12 11 SEP 75 AREA = 11.01 SQ CM HEIGHT = 3.9 CM
DOTTED LINE: ORIGINAL DATA HEAVY LINE: MODEL PREDICTION



3-PARAMETER SOL II MODEL WITH VALUES OF
A1 = .012511, X1 = 4.03229E-03, A2 = .011948
DELTA TIME = 4
ERROR (USING ALL POINTS): 0.6062%
ERROR (IGNORING FIRST 3 POINTS): 1.1312%

6.2

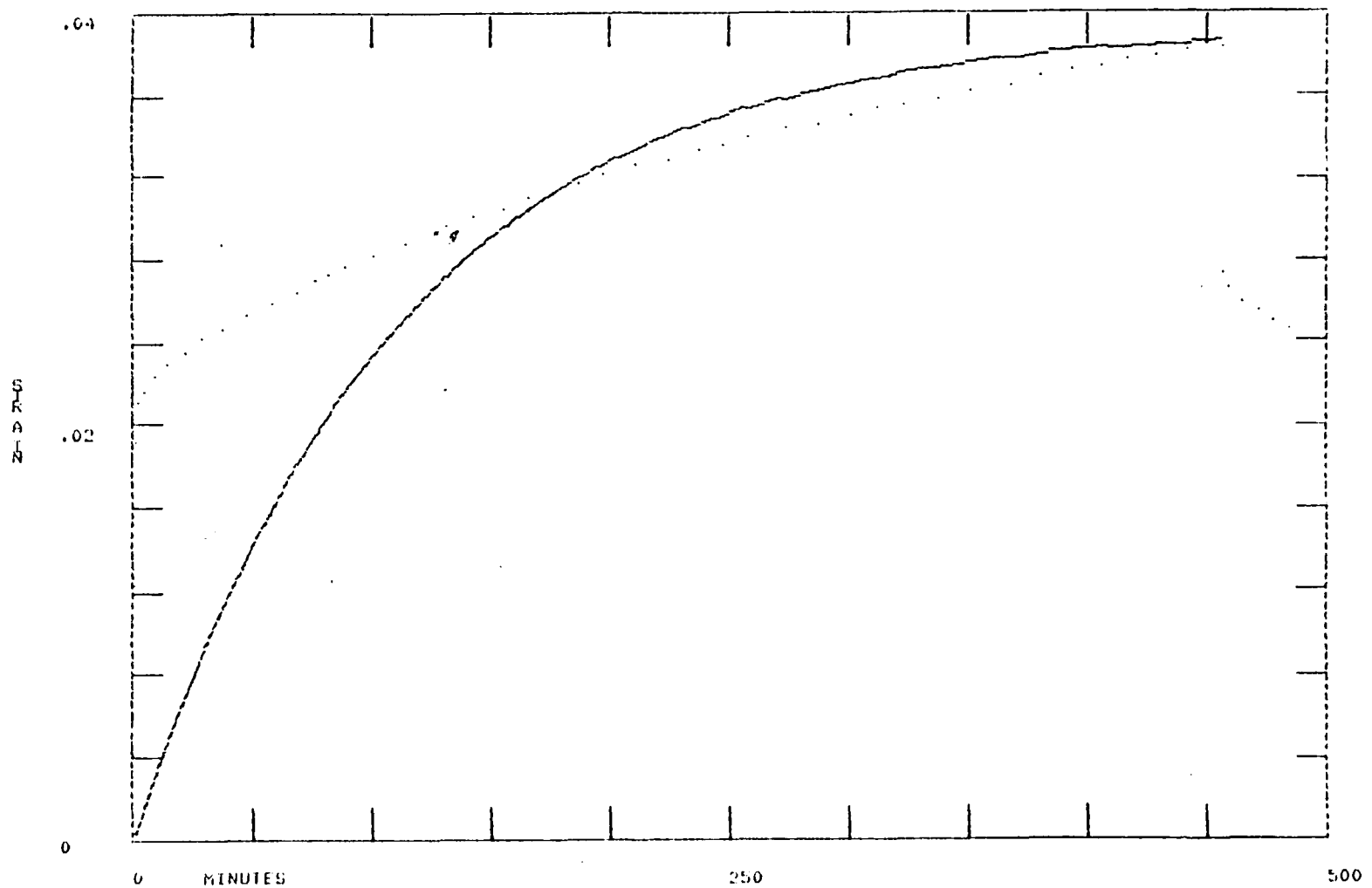
LK-27 LI-12 11 SEP 75 AREA = 11.81 SQ CM HEIGHT = 3.9 CM
DOTTED LINE: ORIGINAL DATA HEAVY LINE: MODEL PREDICTION



4-PARAMETER SOLID MODEL WITH VALUES OF
A1 = .012194, B1 = .50722, A2 = 6.1838E-03, B2 = .005429

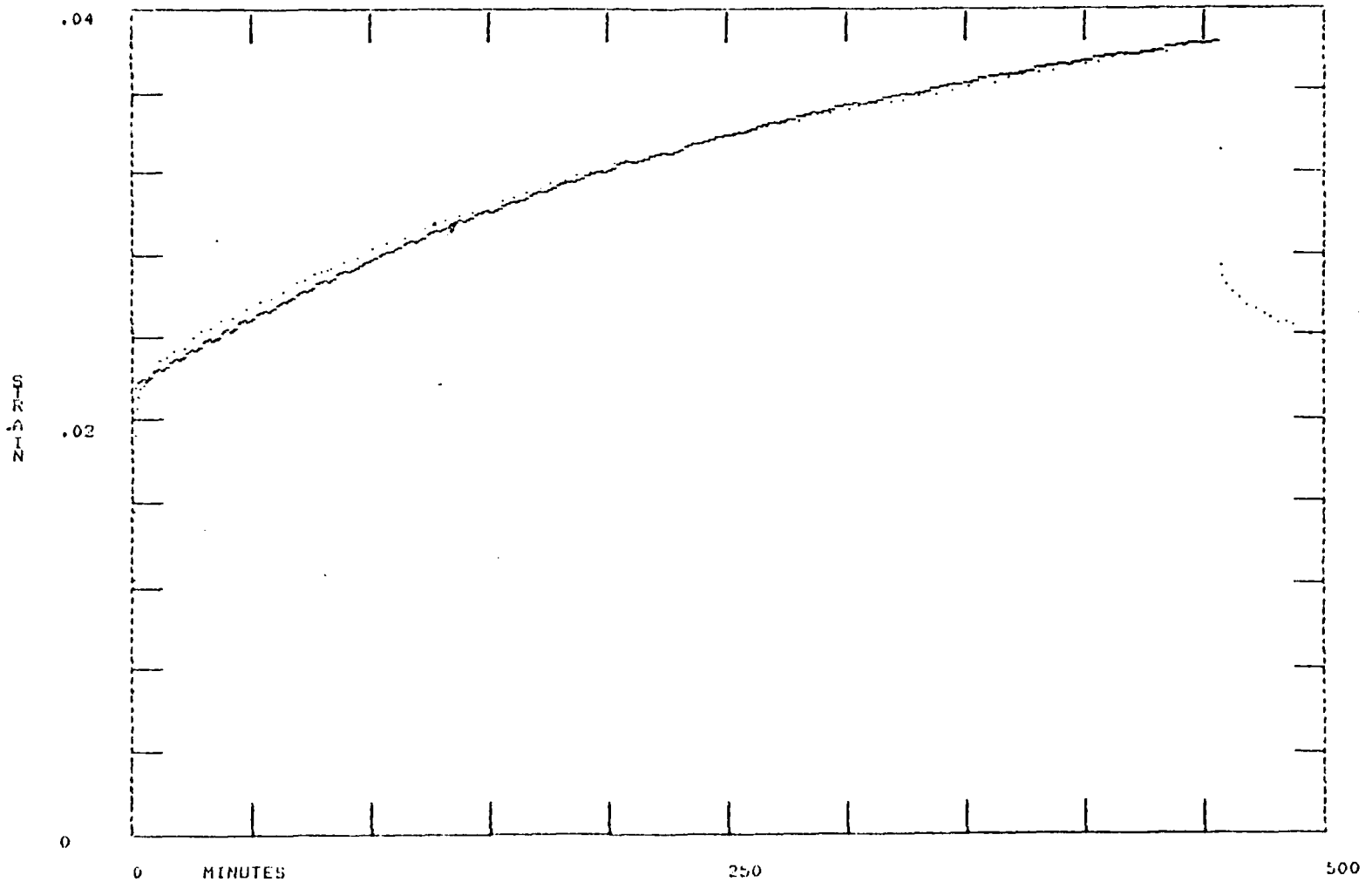
DELTA TIME = 8
ERROR (USING ALL POINTS): 3.684%
ERROR (IGNORING FIRST 3 POINTS): 2.867%

LN-27 L1-L2 11 SEP 75 AREA = 11.01 50 CM HEIGHT = 3.9 CM
DOTTED LINE: ORIGINAL DATA HEAVY LINE: MODEL PREDICTION



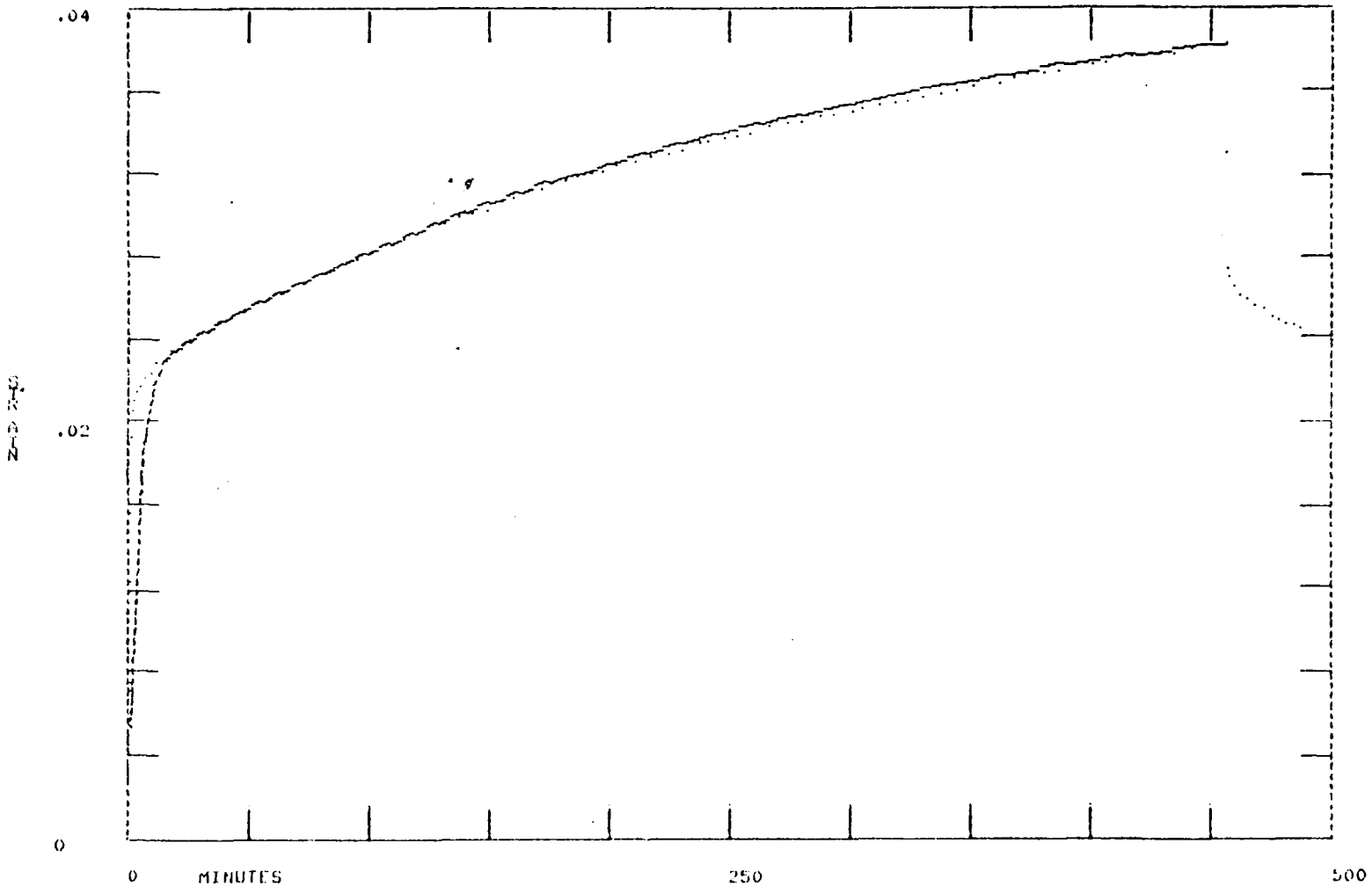
2-PARAMETER SOLID MODEL WITH VALUES OF
AL = .0392288, BL = .0090227
DELTA TIME = 8
ERROR (USING ALL POINTS): 14.801%
ERROR (IGNORING FIRST 3 POINTS): 12.561%

IN-28 L2-13 31 JUN 75 AREA = 14.22 SQ CM HEIGHT = 3.535 CM
DOTTED LINE: ORIGINAL DATA HEAVY LINE: MODEL PREDICTION



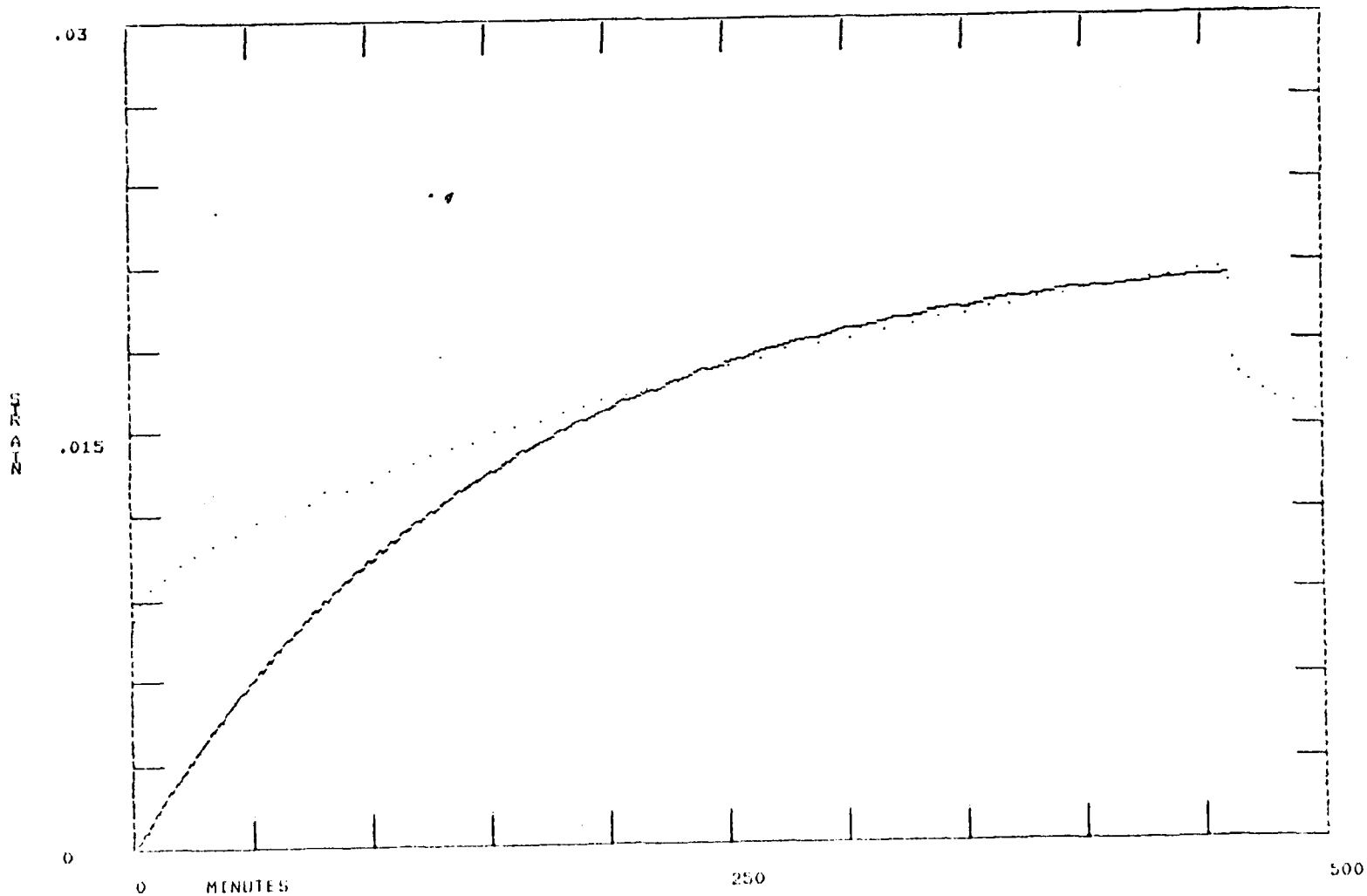
3-PARAMETER SOLID MODEL WITH VALUES OF
A1 = .0422922, B1 = 3.4299E-03, A2 = .0221625
DELTA TIME = 4
ERROR (USING ALL POINTS): -1.708%
ERROR (IGNORING FIRST 3 POINTS): -0.516%

LN-28 L2-L3 31 JUN 75 AREA = 14.22 SQ CM HEIGHT = 3.535 CM
DOTTED LINE: ORIGINAL DATA HEAVY LINE: MODEL PREDICTION



4-PARAMETER SOLID MODEL WITH VALUES OF
A1 = .020006, B1 = 3.6037E-03, A2 = .022225?, B2 = .28225?
DELTA TIME = 4
ERROR (USING ALL POINTS): 2.054%
ERROR (IGNORING FIRST 3 POINTS): 1.869%

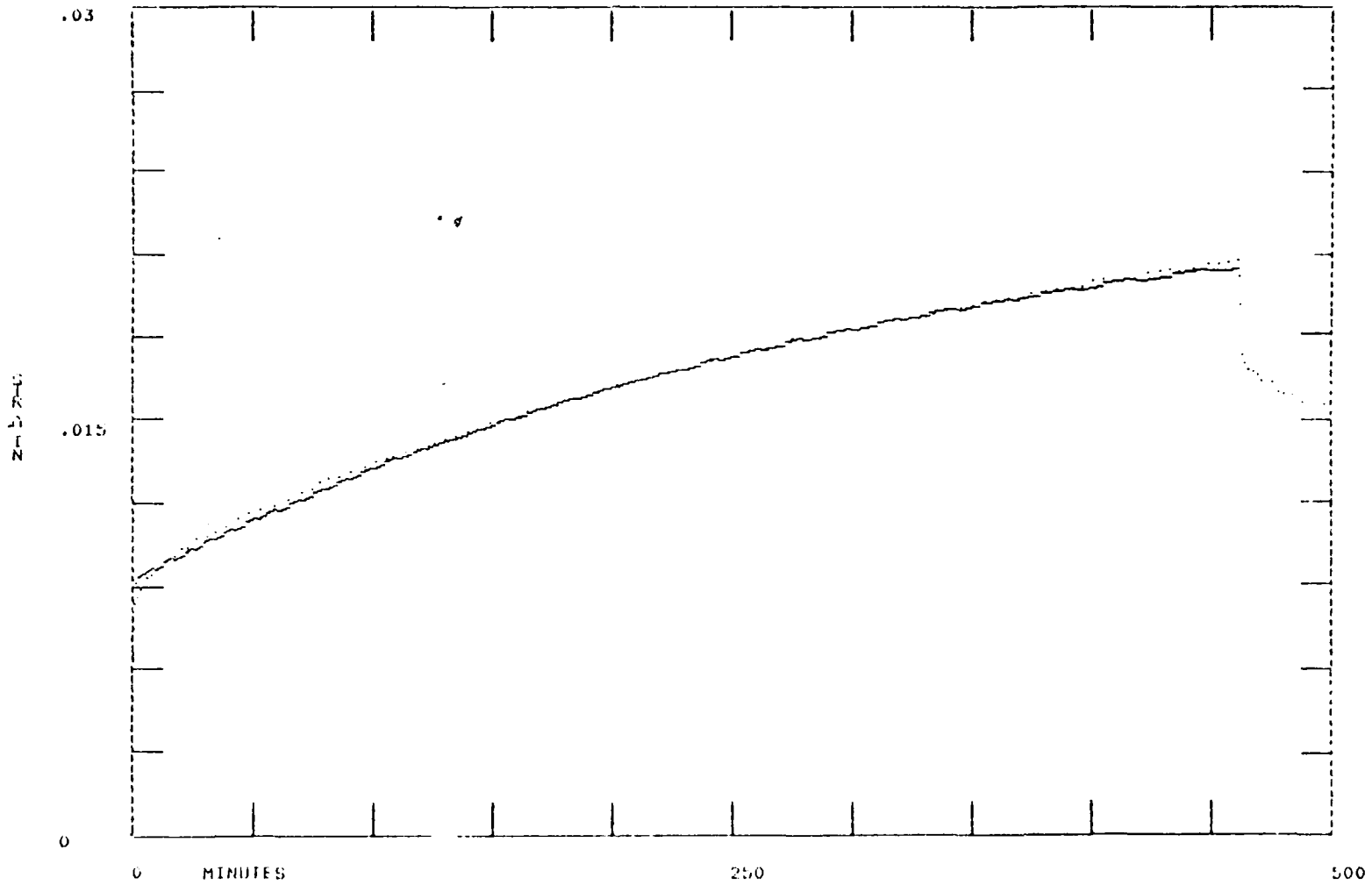
LK-28 12-L3 31 JUN 75 AREA = 14.22 SQ CM HEIGHT = 3.535 CM
DOTTED LINE: ORIGINAL DATA HEAVY LINE: MODEL PREDICTION



2-PARAMETER SOLID MODEL WITH VALUES OF
AL = .0215666 BL = 5.5924E-03
DELTA TIME = 8
ERROR (USING ALL POINTS): 13.103%
ERROR (IGNORING FIRST 3 POINTS): 10.760%

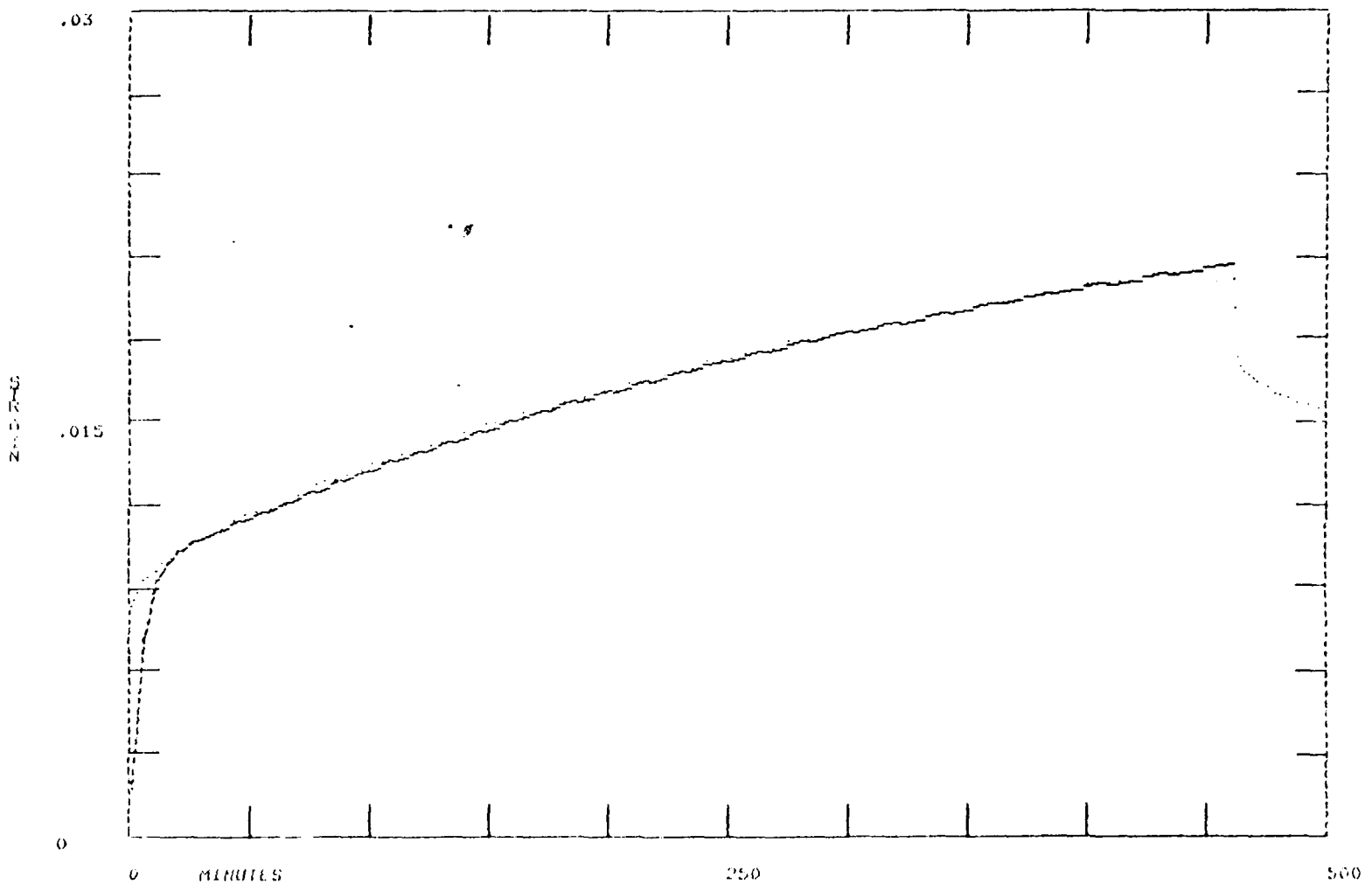
(7)

LR-29 L3-L4 14 AUG 75 AREA = 14.17 SQ CM HEIGHT = 3.165 CM
DOTTED LINE: ORIGINAL DATA HEAVY LINE: MODEL PREDICTION



3-PARAMETER SOLID MODEL WITH VALUES OF
A1 = .0233963, B1 = 3.18641E-03, A2 = 9.23835E-03
DELTA TIME = 4
ERROR (USING ALL POINTS): -0.068%
ERROR (IGNORING FIRST 3 POINTS): 0.326%

LR-29 L3-L4 14 AUG 75 AREA = 14.17 SQ CM HEIGHT = 3.165 CM
DOTTED LINE: ORIGINAL DATA HEAVY LINE: MODEL PREDICTION



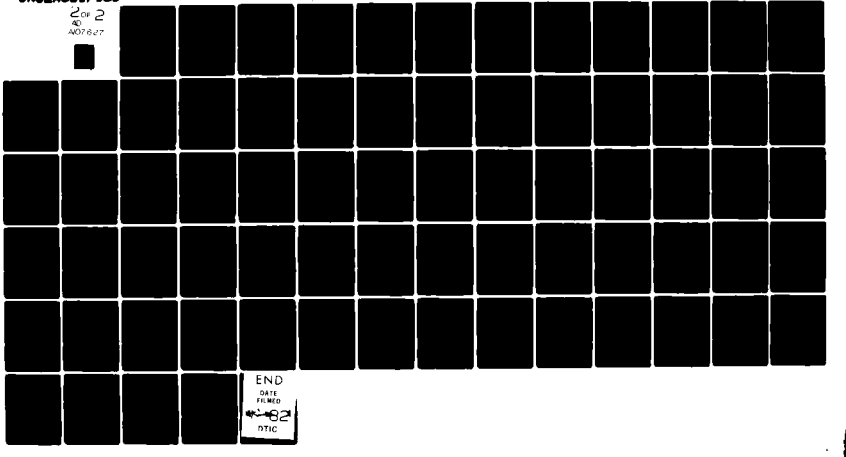
4 PARAMETER SOLID MODEL WITH VALUES OF
A1 = 9.65532E-03, B1 = .20838, A2 = .016172, B2 = 2.5349E-03
DELTA TIME = 4
ERROR (USING ALL POINTS): 2.1227%
ERROR (IGNORING FIRST 3 POINTS): 1.5226%

14 AUG 75 AREA = 14.17 SQ CM HEIGHT = 3.165 CM
LIGHT LINE: ORIGINAL DATA HEAVY LINE: MODEL PREDICTION

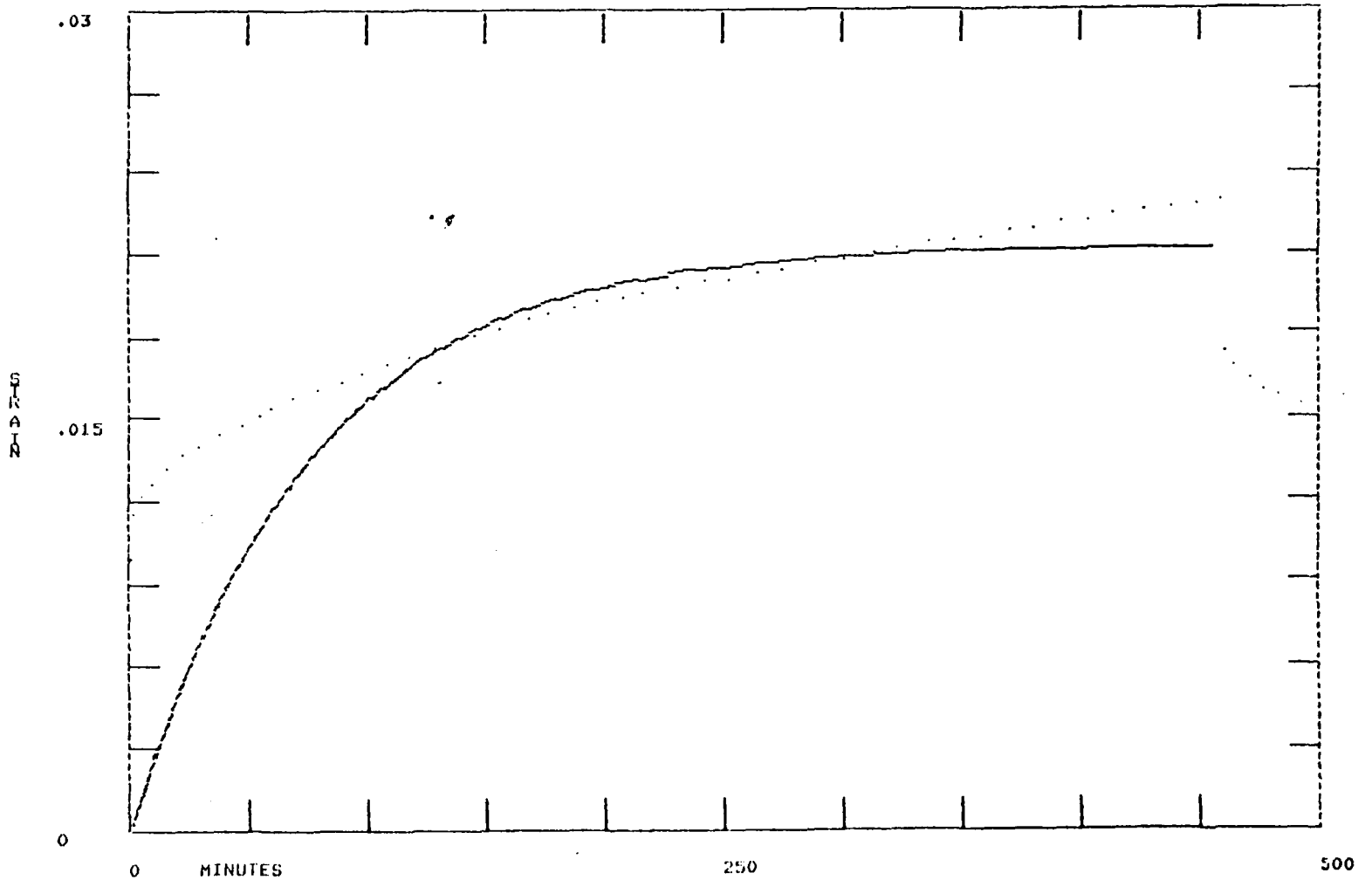
AD-A107 627 TUSKEGEE INST AL DEPT OF PHYSICS F/G 6/4
ANALYTICAL MODELLING OF LOAD-DEFLECTION BEHAVIOR INTERVERTEBRAL--ETC(U)
1980 M L BURNS AFOSR-80-0115
AFOSR-TR-81-0653 NL

UNCLASSIFIED

2 OF 2
AD
A107 627



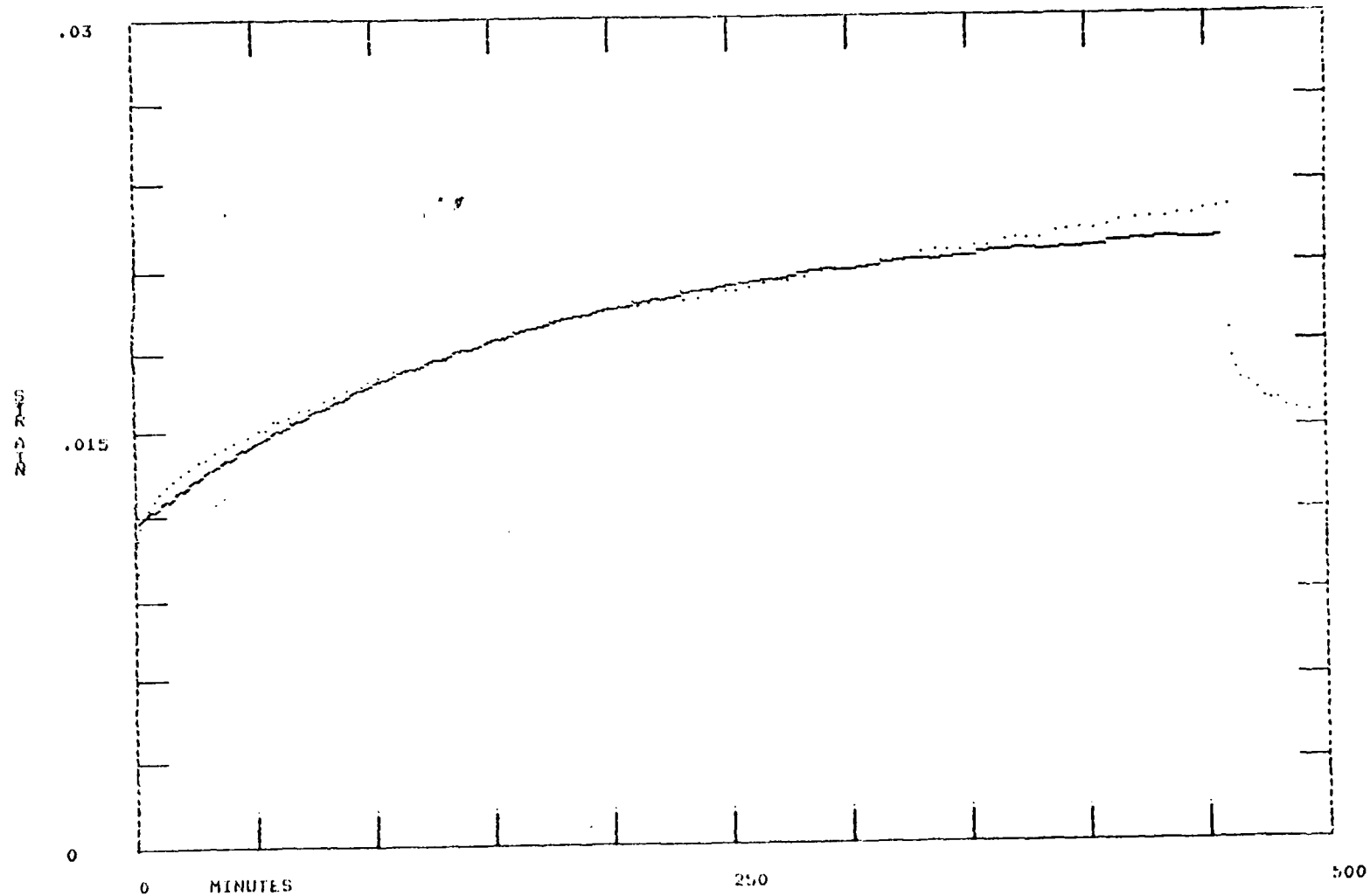
END
DATE FILMED
-82
DTIC



2-PARAMETER SOLID MODEL WITH VALUES OF
AL = .022345, BL = .013233
DELTA TIME = 4
ERROR (USING ALL POINTS): 11.5322%
ERROR (IGNORING FIRST 3 POINTS): 9.2274%

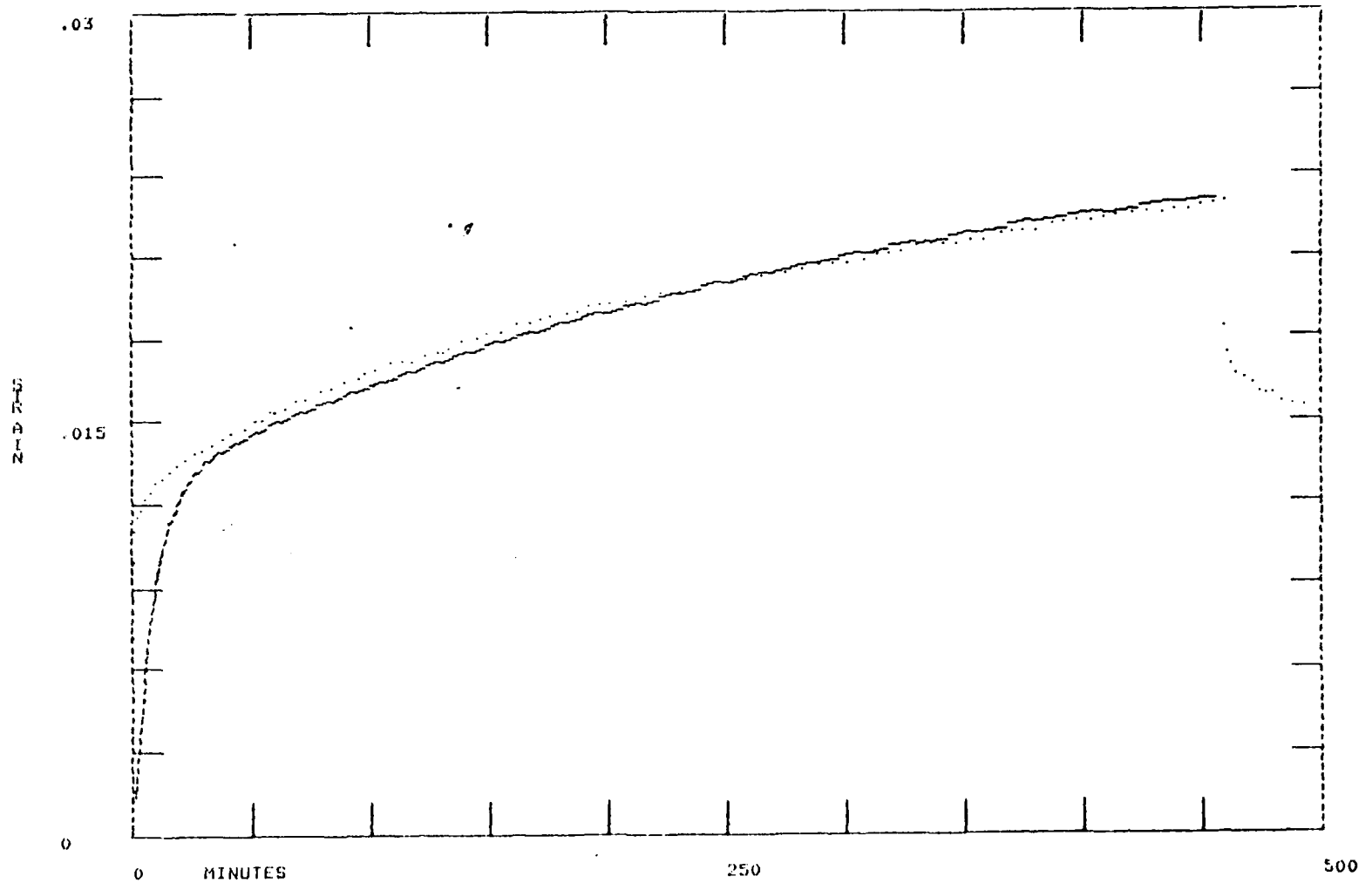
LN-30 L4-L5 16 AUG 75 AREA = 17.22 SQ CM HEIGHT = 3.16 CM
DOTTED LINE: ORIGINAL DATA HEAVY LINE: MODEL PREDICTION

10



3-PARAMETER SOLID MODEL WITH VALUES OF
A1 = .022682, B1 = 5.9945E-03, A2 = .011707
DELTA TIME = 30
ERROR (USING ALL POINTS): 0.106%
ERROR (IGNORING FIRST 3 POINTS): 0.932%

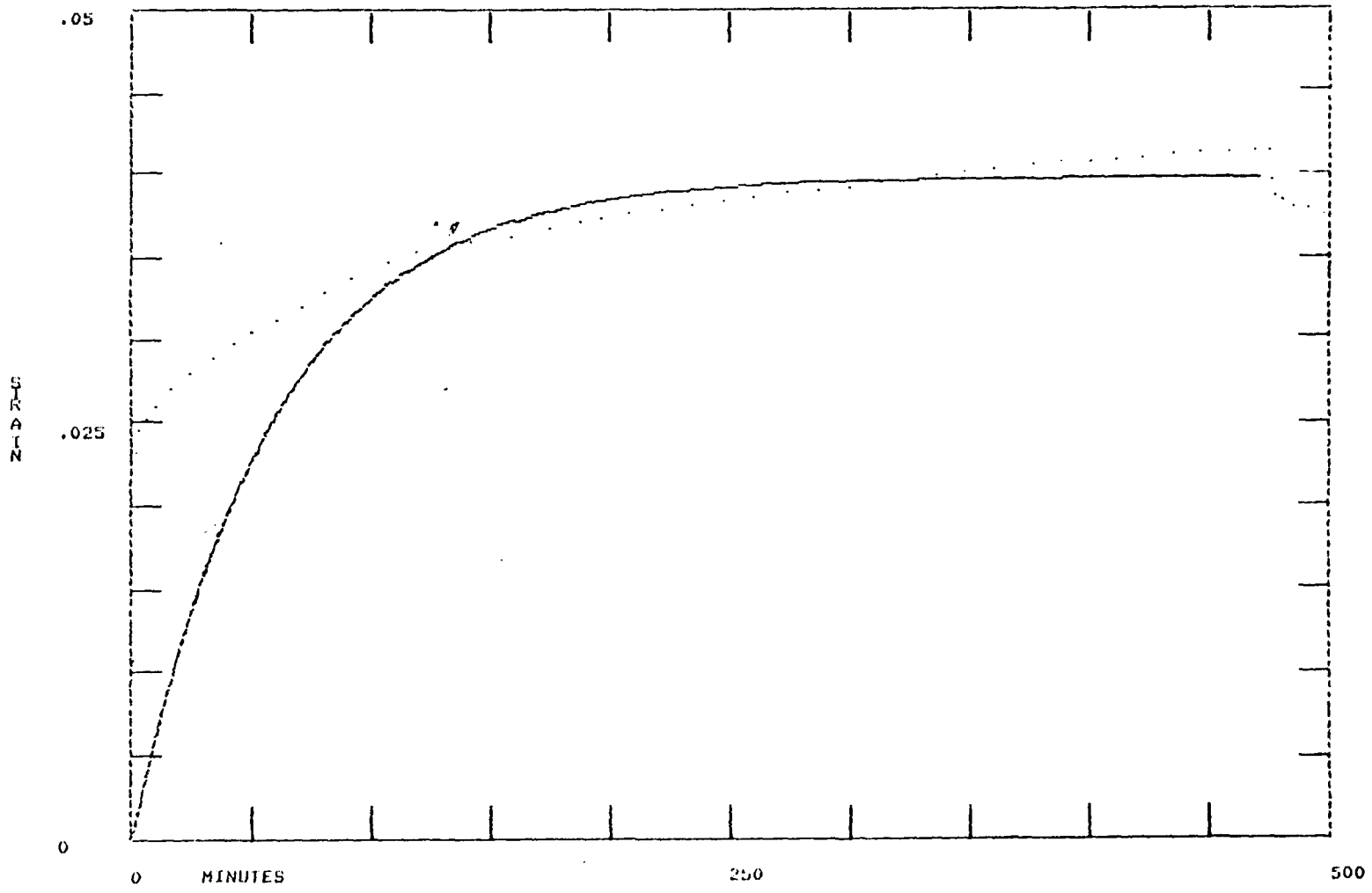
LN-30 L4-L5 16 AUG 75 AREA = 17.22 SQ CM HEIGHT = 3.16 CM
DOTTED LINE: ORIGINAL DATA HEAVY LINE: MODEL PREDICTION



4-PARAMETER SOLID MODEL WITH VALUES OF
A1 = .012624, B1 = .12204, A2 = .013902, B2 = 3.1061E-03
DELTA TIME = 4
ERROR (USING ALL POINTS): 3.980%
ERROR (IGNORING FIRST 3 POINTS): 3.583%

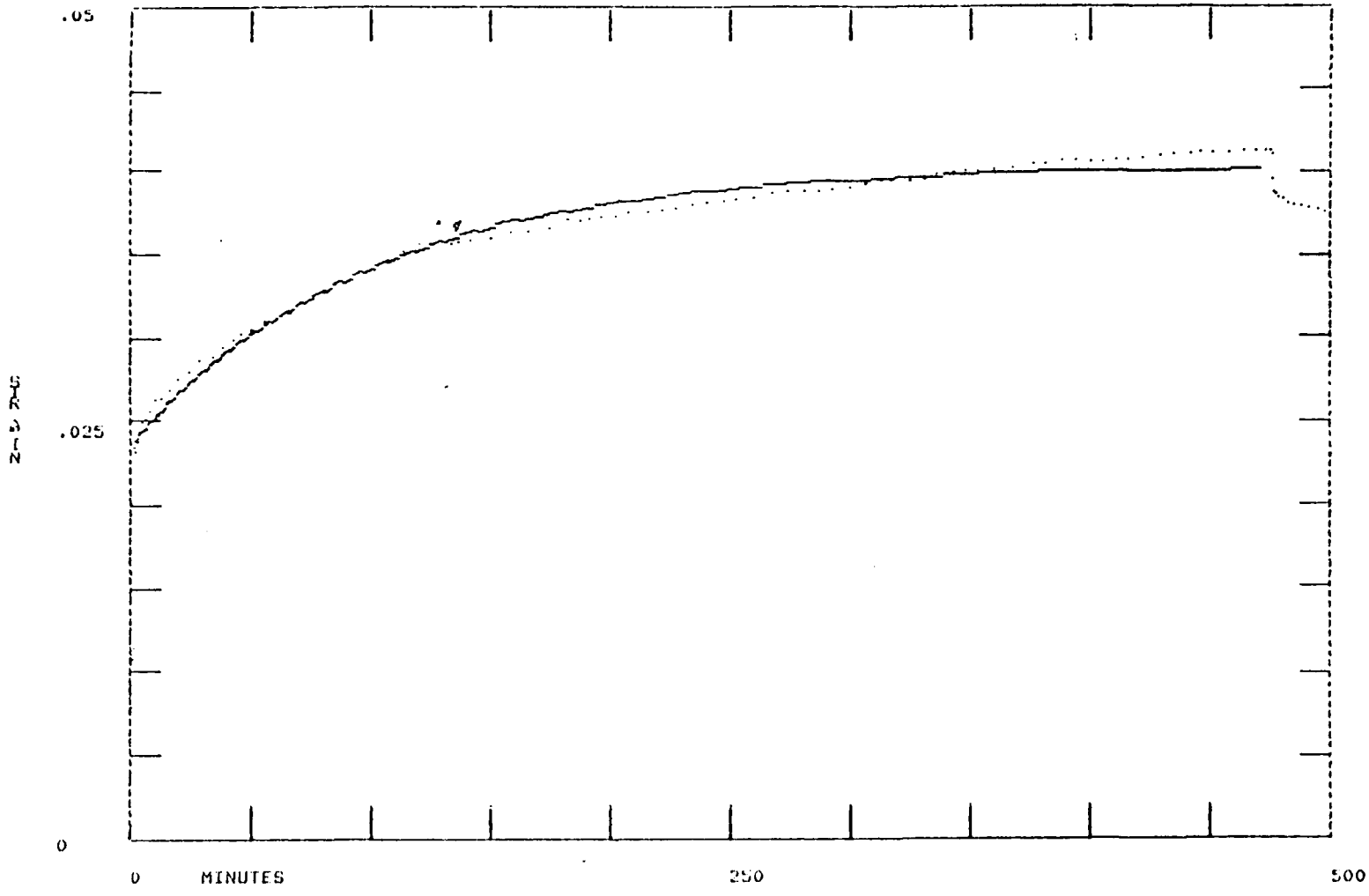
LK-30 L4-L5 16 AUG 75 AREA = 17.22 SQ CM HEIGHT = 3.16 CM
DOTTED LINE: ORIGINAL DATA HEAVY LINE: MODEL PREDICTION

14



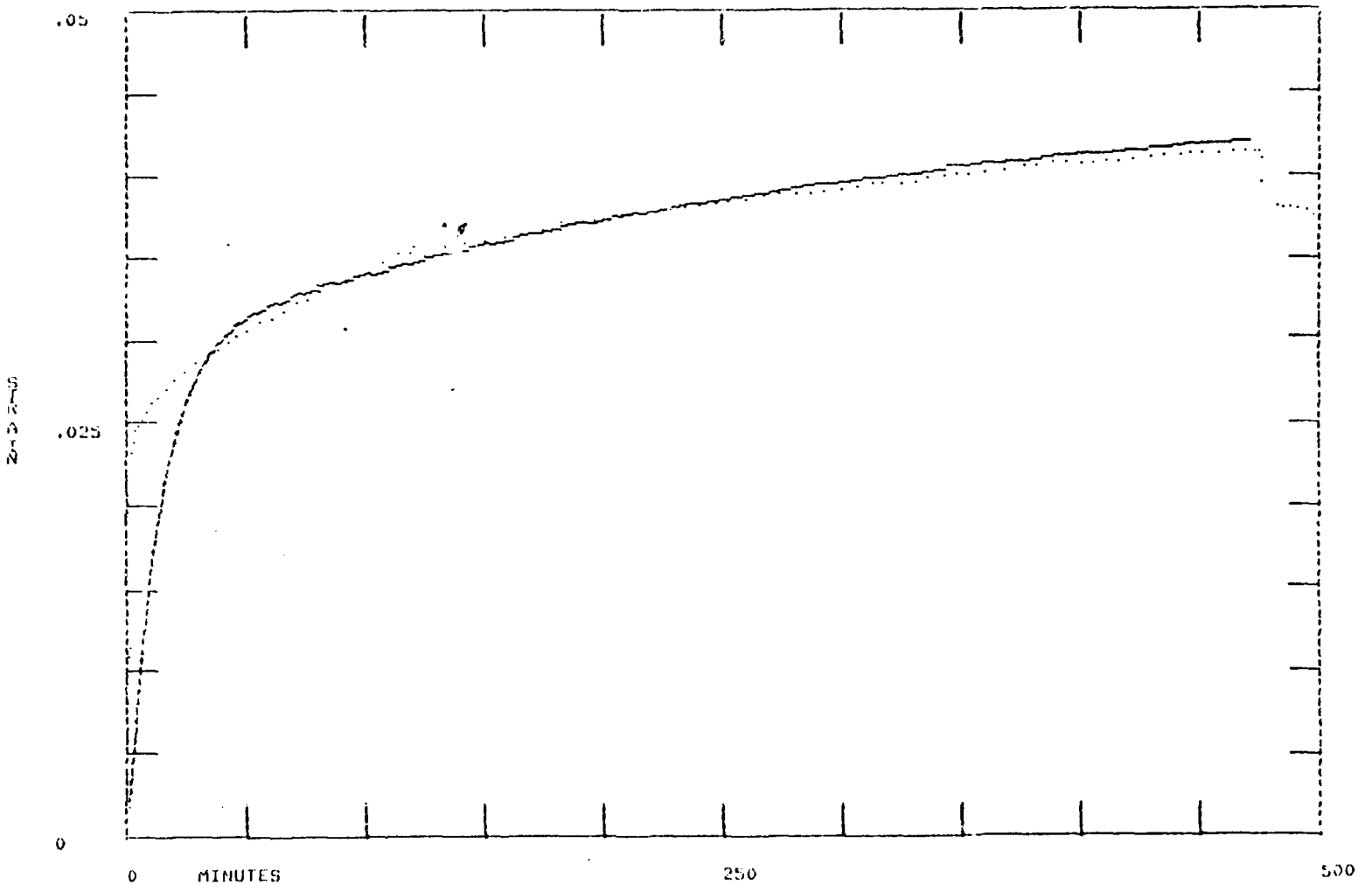
2-PARAMETER SOLID MODEL WITH VALUES OF
AL = .039253, BL = .017024
DELTA TIME = 8
ERROR (USING ALL POINTS): 11.350%
ERROR (IGNORING FIRST 3 POINTS): 9.297%

LN-31 15-SI 18 AUG 75 AREA = 25.61 SQ CM HEIGHT = 3.76 CM
DOTTED LINE: ORIGINAL DATA HEAVY LINE: MODEL PREDICTION



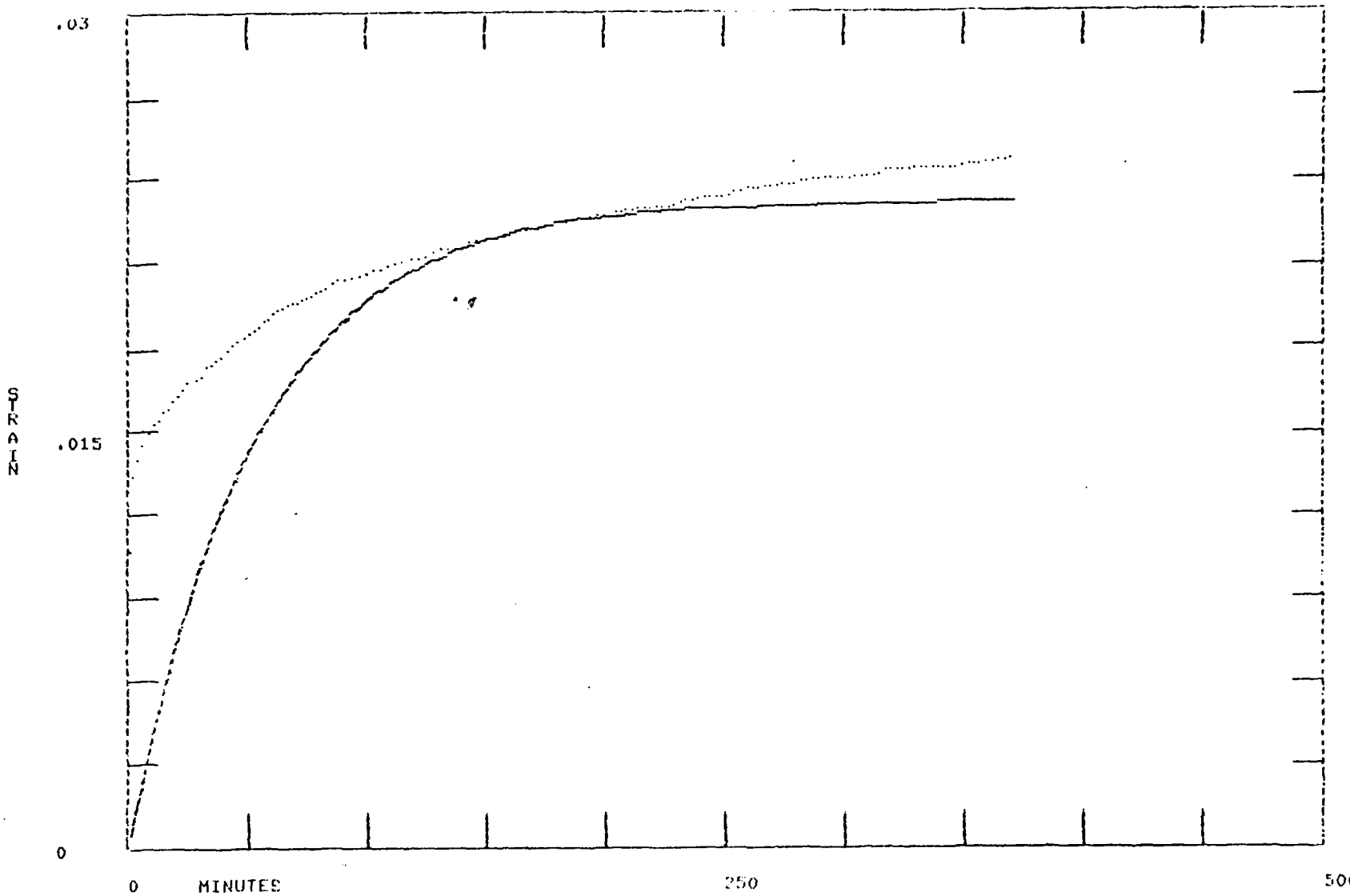
3-PARAMETER SOLID MODEL WITH VALUES OF
A1 = .040361, B1 = .0100911, A2 = .022367
DELTA TIME = 4
ERROR (USING ALL POINTS): -1.598%
ERROR (IGNORING FIRST 3 POINTS): -0.487%

LX-31 LS-S1 18 AUG 75 AREA = 25.61 SQ CM HEIGHT = 3.76 CM
DOTTED LINE: ORIGINAL DATA HEAVY LINE: MODEL PREDICTION



4-PARAMETER SOLID MODEL WITH VALUES OF
A1 = .029506, B1 = .076435, A2 = .015747, B2 = 3.4103E-03
DELTA TIME = 8
ERROR (USING ALL POINTS): 4.096%
ERROR (IGNORING FIRST 3 POINTS): 3.794%

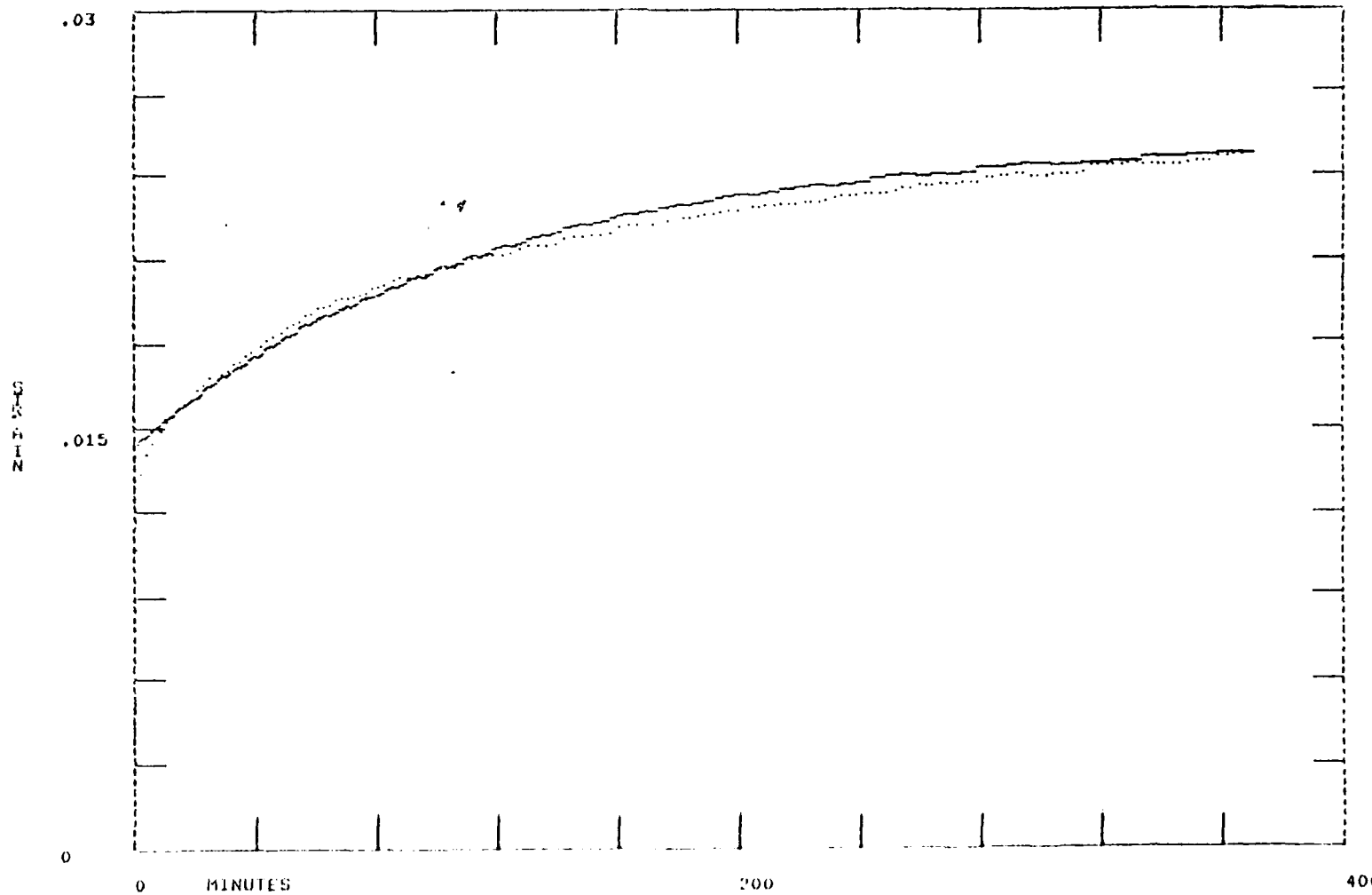
LN-31 15-S1 18 AUG 75 AREA = 25.61 SQ CM HEIGHT = 3.76 CM
DOTTED LINE: ORIGINAL DATA HEAVY LINE: MODEL PREDICTION



2-PARAMETER SOLID MODEL WITH VALUES OF
A1 = 2.319655E-02, B1 = 1.903586E-02, A2 = 0
B2 = 0, A3 = 0 DELTA TIME = 30
ERROR (USING ALL POINTS): 10.069%
ERROR (IGNORING FIRST 3 POINTS): 9.568%

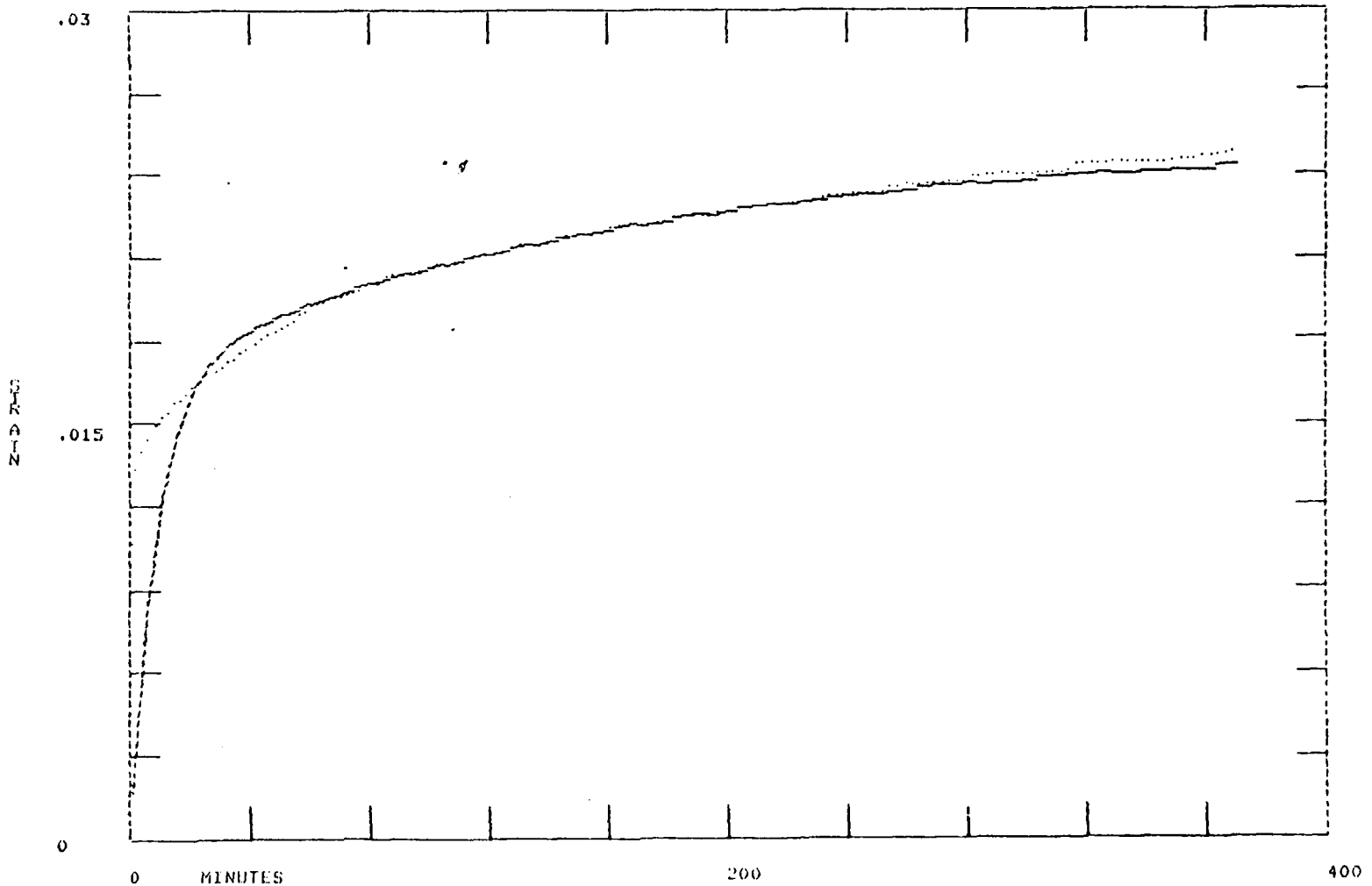
K-42 15-51 28 JAN 75 AREA = 19.21 SQ CM HEIGHT = 4.35 CM
DOTTED LINE: ORIGINAL DATA HEAVY LINE: MODEL PREDICTION

16



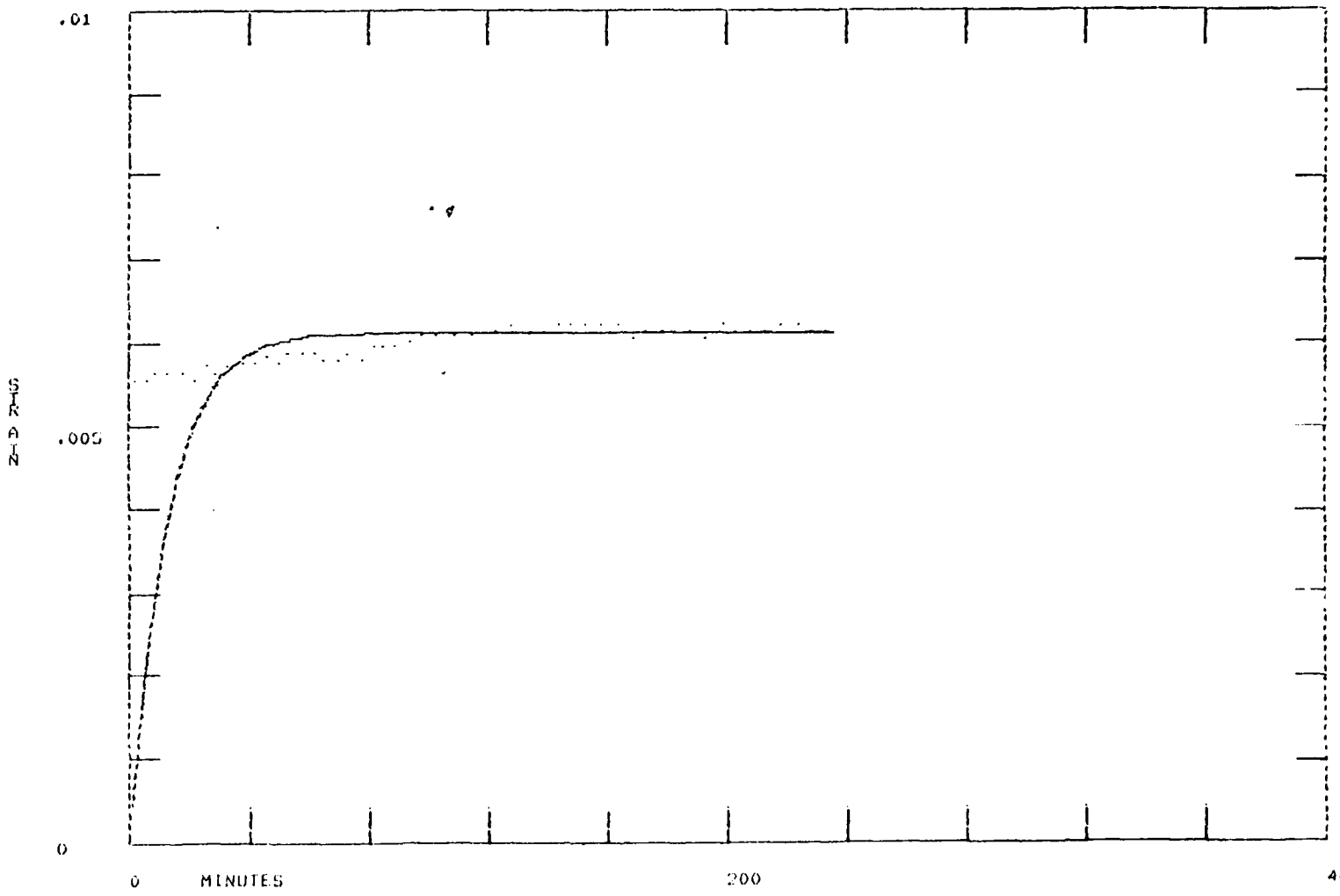
3-PARAMETER SOLID MODEL WITH VALUES OF
G1 = .0225188, K1 = .0008709, G2 = .0143525,
DELTA TIME = 4
ERROR (USING ALL POINTS): =0.711%
ERROR (IGNORING FIRST 3 POINTS): =0.822%

EK-42 15 51 28 JAN 75 AREA = 19.21 SQ CM HEIGHT = 4.35 CM
DOTTED LINE: ORIGINAL DATA HEAVY LINE: MODEL PREDICTION



4-PARAMETER SOLID MODEL WITH VALUES OF
A1 = .016738, B1 = .11152, A2 = .008348, B2 = 6.33364E-03
DELTA TIME = 4
ERROR (USING ALL POINTS): 1.928%
ERROR (IGNORING FIRST 3 POINTS): 1.424%

LK-42 LS-S1 28 JAN 75 AREA = 19.21 SQ CM HEIGHT = 4.35 CM
DOTTED LINE: ORIGINAL DATA HEAVY LINE: MODEL PREDICTION



2-PARAMETER SOLID MODEL WITH VALUES OF
A1 = 6.13022E-03, B1 = .079488

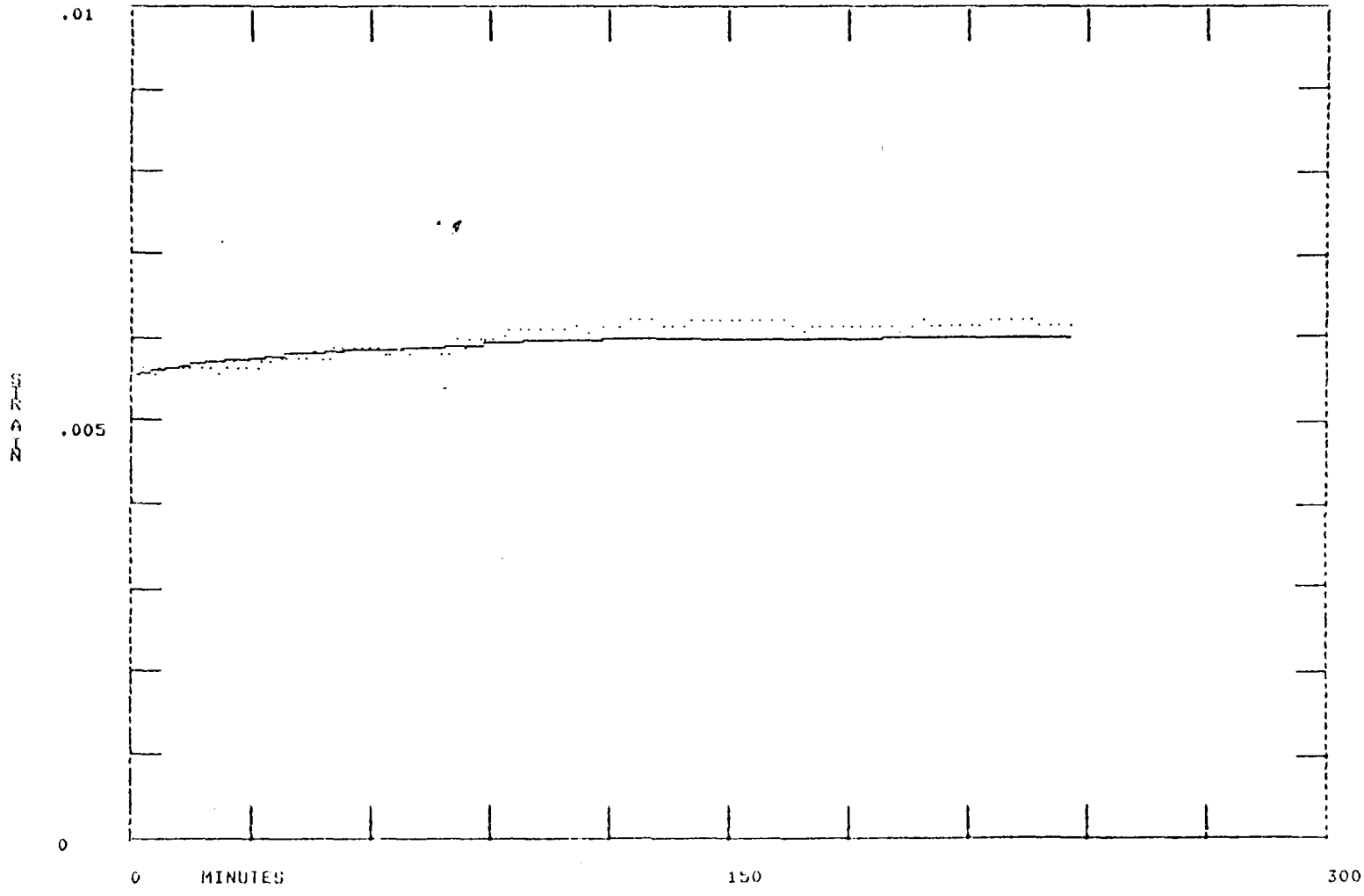
DELTA TIME = 8

ERROR (USING ALL POINTS): 3.968%

ERROR (IGNORING FIRST 3 POINTS): 0.641%

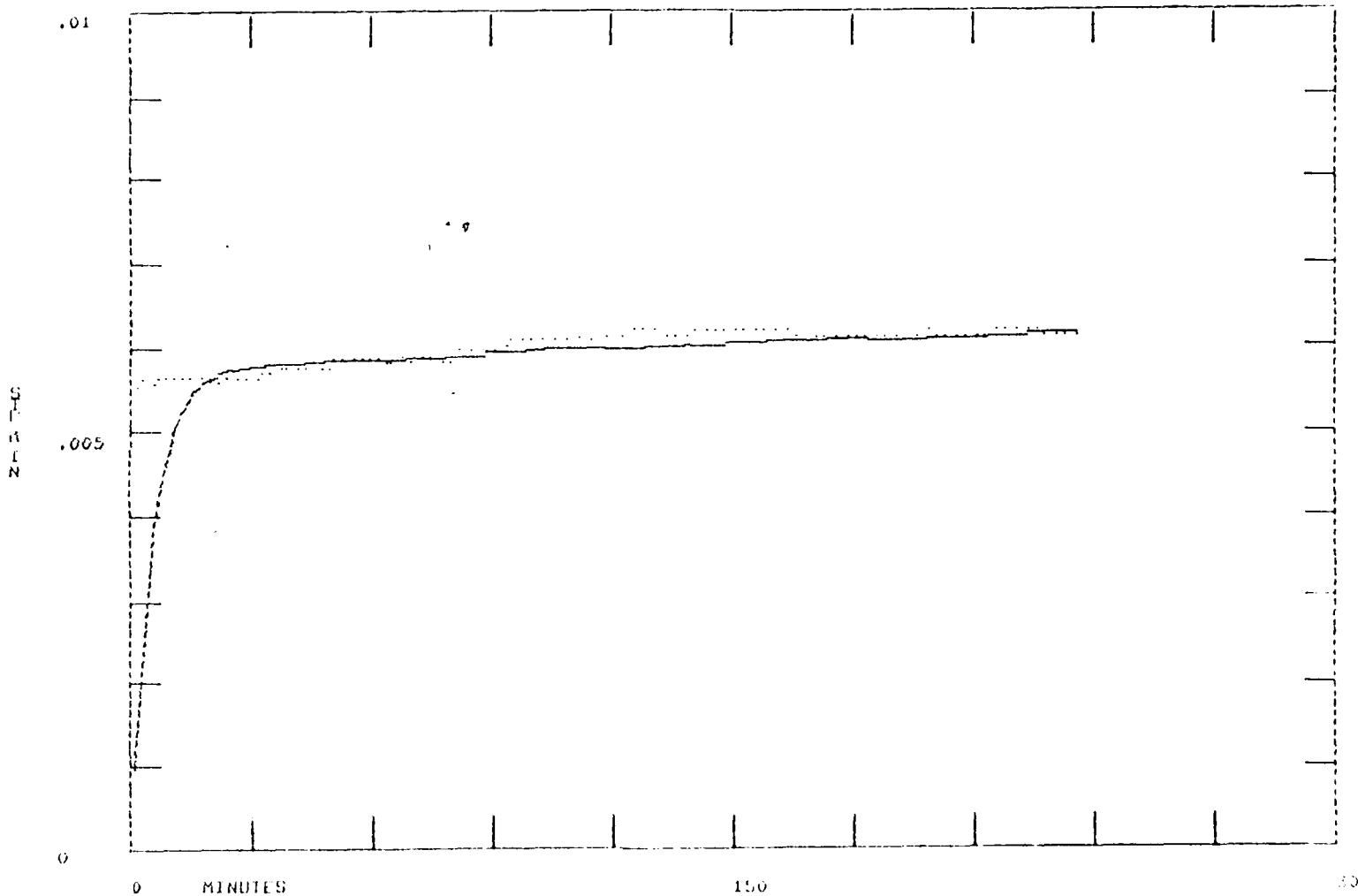
LN-44 L3-L4 30 JAN 75 AREA = 19.64 SQ CM HEIGHT = 4.09 CM

DOTTED LINE: ORIGINAL DATA HEAVY LINE: MODEL PREDICTION



3-PARAMETER SOLID MODEL WITH VALUES OF
A1 = 6.0182E-03, B1 = .01706, A2 = 5.5612E-03
DELTA TIME = 1.6
ERROR (USING ALL POINTS): 1.489%
ERROR (IGNORING FIRST 3 POINTS): 1.509%

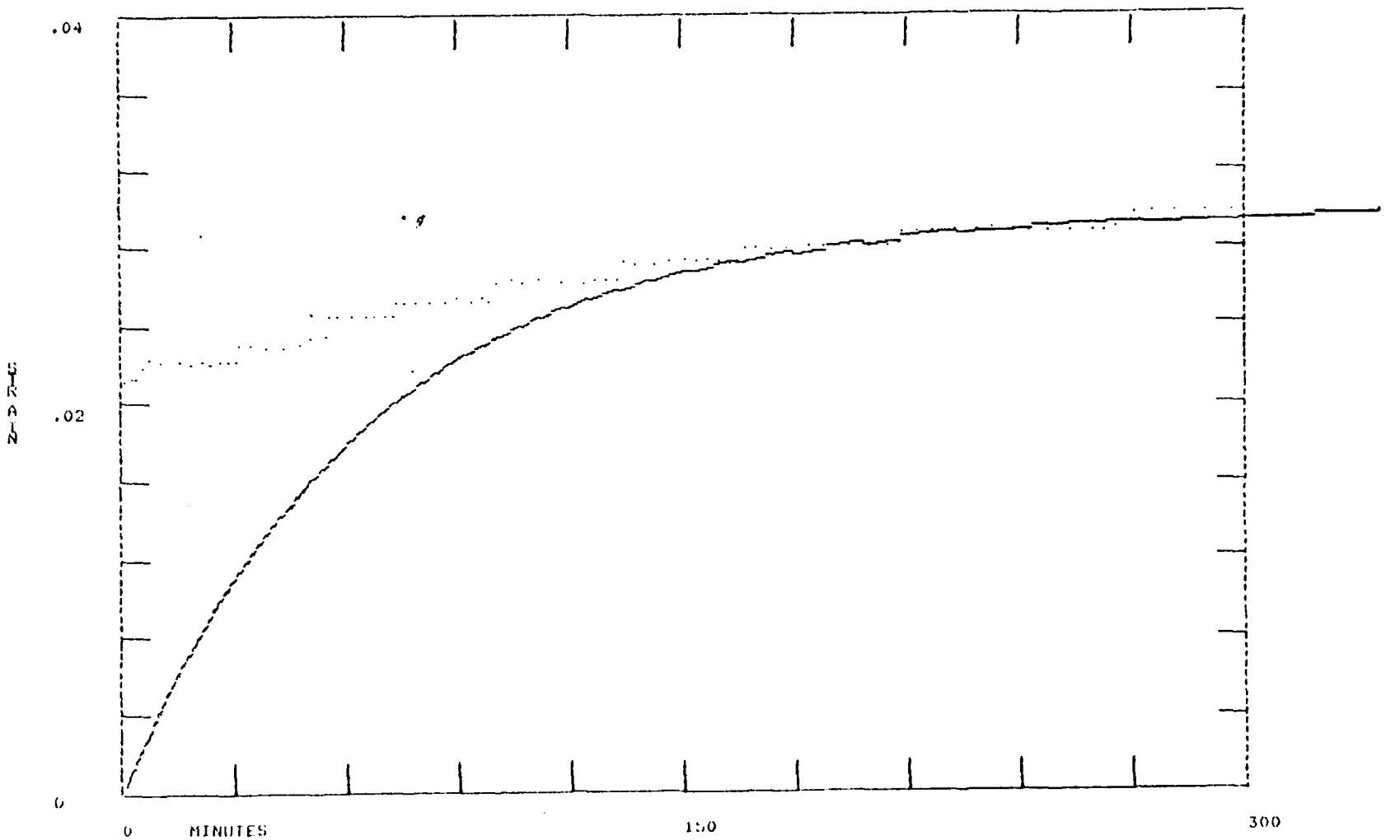
LN-44 L3-L4 30 JAN 75 AREA = 19.64 SQ CM HEIGHT = 4.09 CM
DOTTED LINE: ORIGINAL DATA HEAVY LINE: MODEL PREDICTION



4-PARAMETER SOLID MODEL WITH VALUES OF
A1 = 9.2493E-04, B1 = 2.9139E-03, A2 = 5.2141E-03, B2 = .19552
DELTA TIME = 1.6
ERROR (USING ALL POINTS): 2.0662%
ERROR (IGNORING FIRST 3 POINTS): 1.0612%

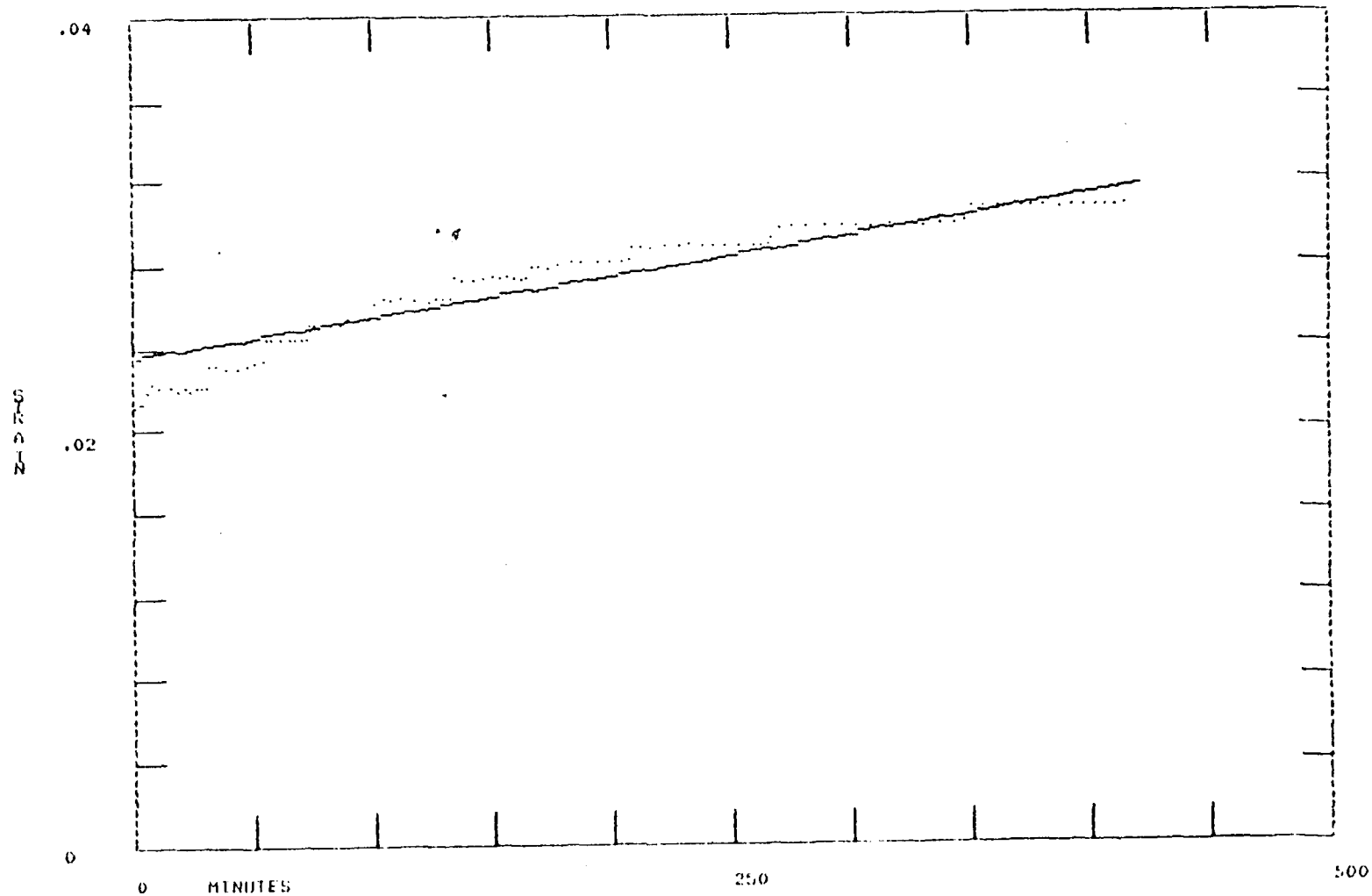
LN 44 L3-L4 30 JAN 75 AREA = 19.64 SQ CM HEIGHT = 4.09 CM
DOTTED LINE: ORIGINAL DATA HEAVY LINE: MODEL PREDICTION

41



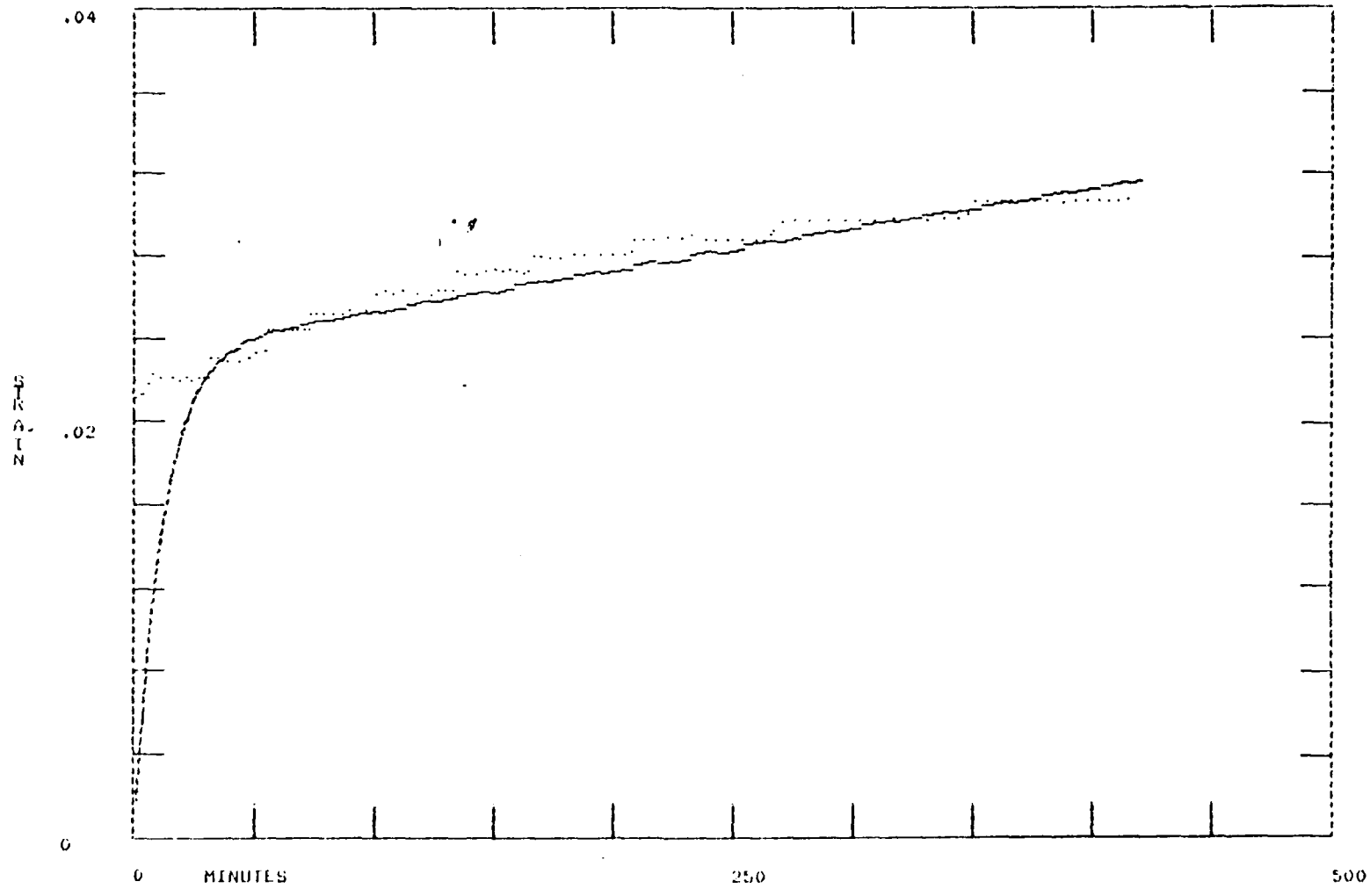
2-PARAMETER SOLID MODEL WITH VALUES OF
AL = .0229656, BL = .0155358
DELTA TIME = 4
ERROR (USING ALL POINTS): 18.359%
ERROR (IGNORING FIRST 3 POINTS): 17.481%

LN-45 L2-13 31 JAN 75 AREA = 18.52 SQ CM HEIGHT = 2.635 CM
DOTTED LINE: ORIGINAL DATA HEAVY LINE: MODEL PREDICTION



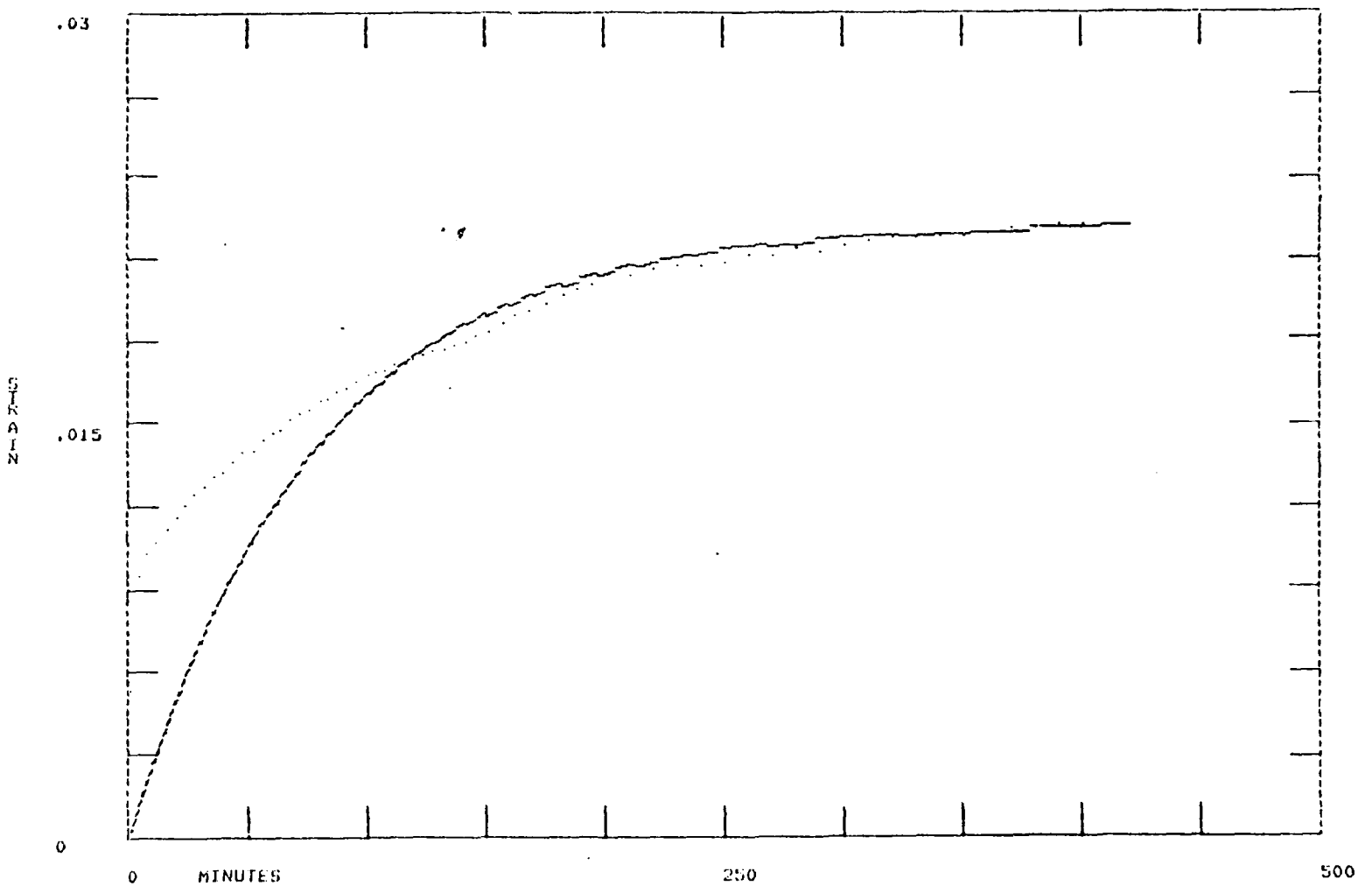
3-PARAMETER SOLID MODEL WITH VALUES OF
G1 = 6.55512, B1 = 2.9643E-06, G2 = .023559
DELTA TIME = 6
ERROR (USING ALL POINTS): 1.451%
ERROR (IGNORING FIRST 3 POINTS): 0.584%

LK-45 L2-L3 31 JAN 75 AREA = 18.52 SQ CM HEIGHT = 2.635 CM
DOTTED LINE: ORIGINAL DATA HEAVY LINE: MODEL PREDICTION



4-PARAMETER SOLID MODEL WITH VALUES OF
A1 = .0822914, B1 = 2.55516E-04, A2 = .0233253, B2 = .086721
DELTA TIME = 8
ERROR (USING ALL POINTS): 5.910%
ERROR (IGNORING FIRST 3 POINTS): 5.082%

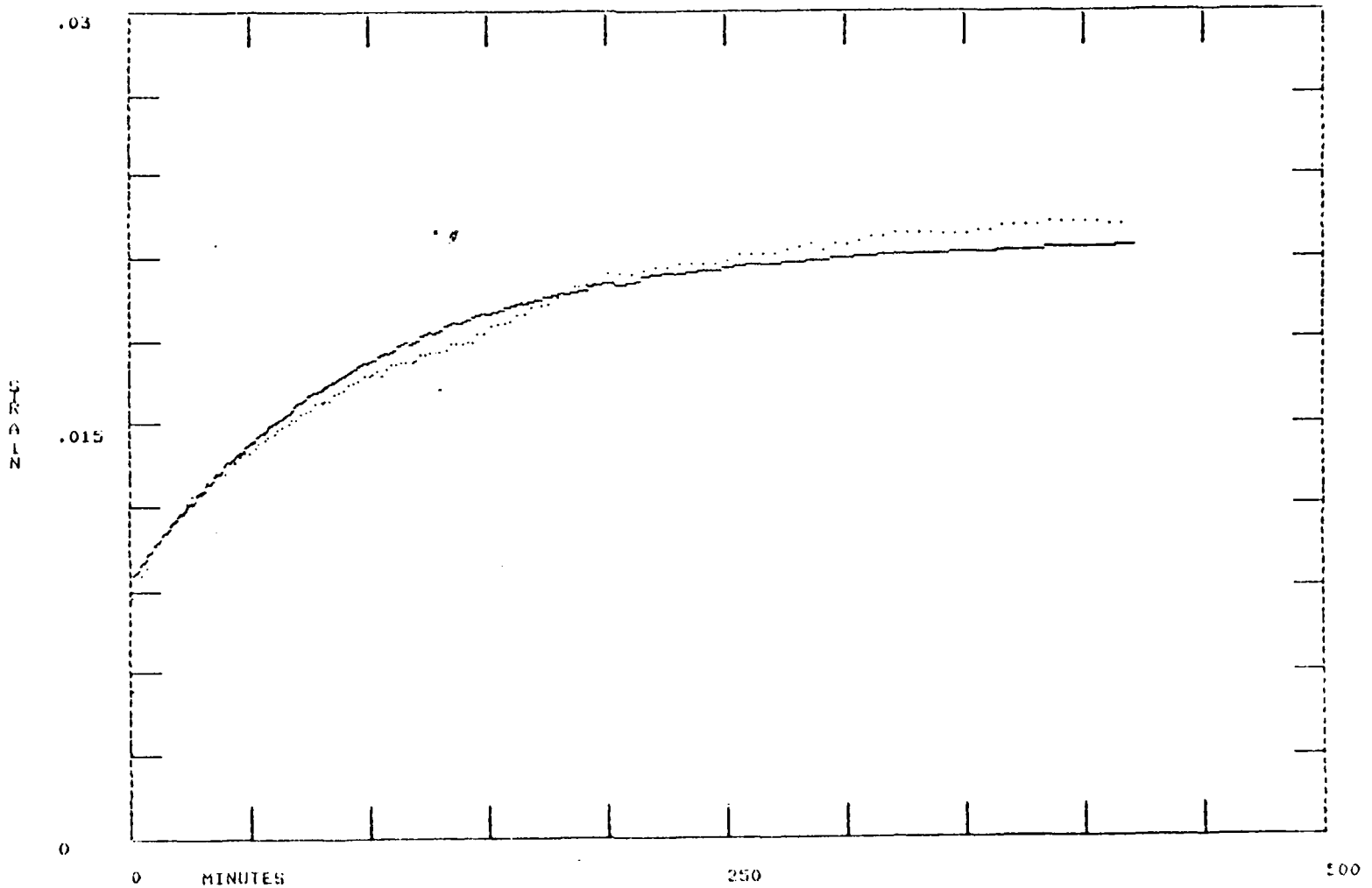
LN-45 12-13 31 JAN 75 AREA = 10.52 SQ CM HEIGHT = 2.635 CM
DOTTED LINE: ORIGINAL DATA HEAVY LINE: MODEL PREDICTION



2-PARAMETER SOLID MODEL WITH VALUES OF
AL = .0222258, BL = .012827
DELTA TIME = 30
ERROR (USING ALL POINTS): 2.680%
ERROR (IGNORING FIRST 3 POINTS): 5.996%

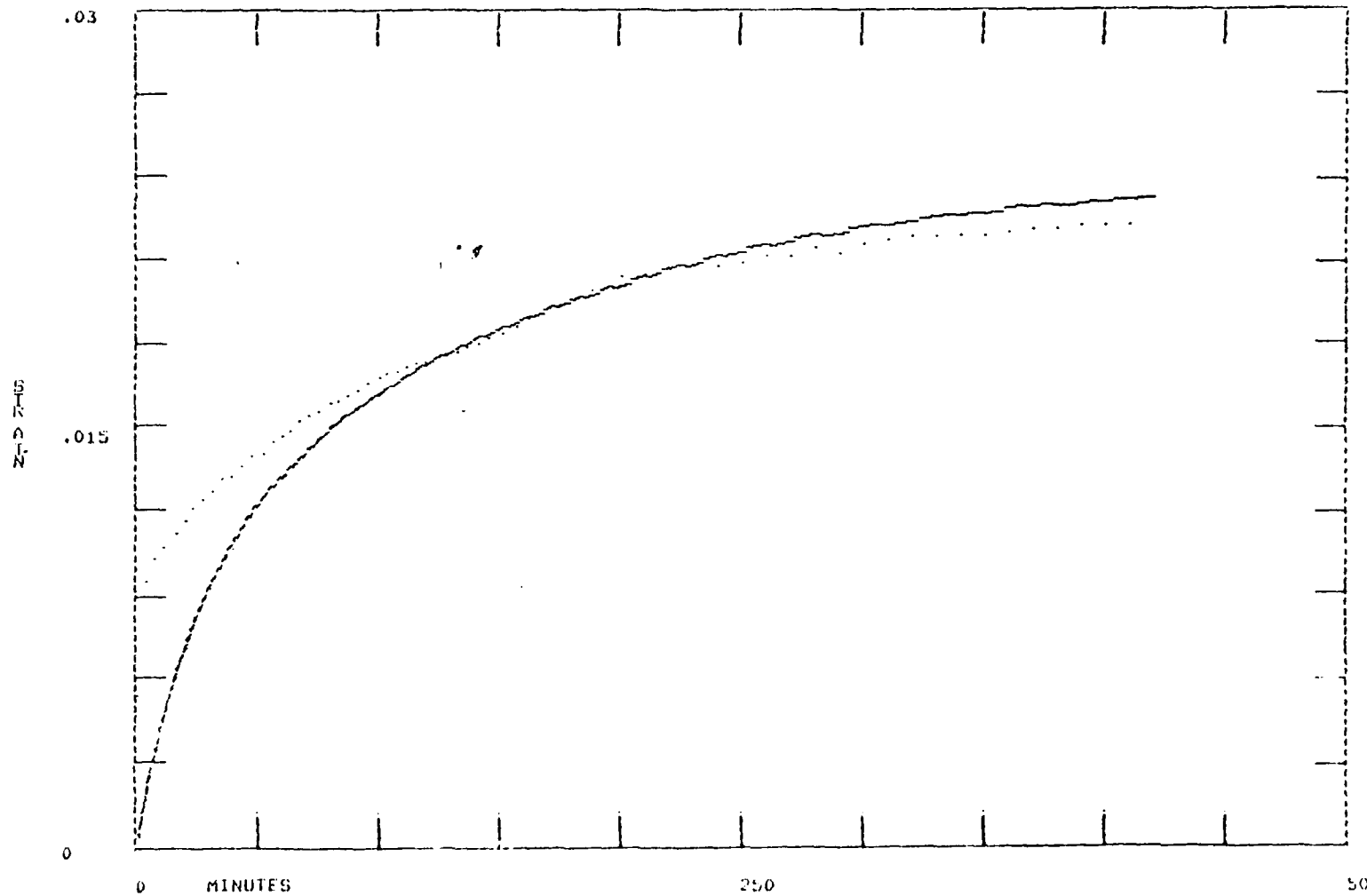
LN-47 T11-T12 04 FEB 75 AREA = 19.35 SQ CM HEIGHT = 2.709 CM
DOTTED LINE: ORIGINAL DATA HEAVY LINE: MODEL PREDICTION

85



3-PARAMETER SOLID MODEL WITH VALUES OF
A1 = .022585, B1 = .010397, A2 = 9.3346E-03
DELTA TIME = 4
ERROR (USING ALL POINTS): -0.410%
ERROR (IGNORING FIRST 3 POINTS): -0.217%

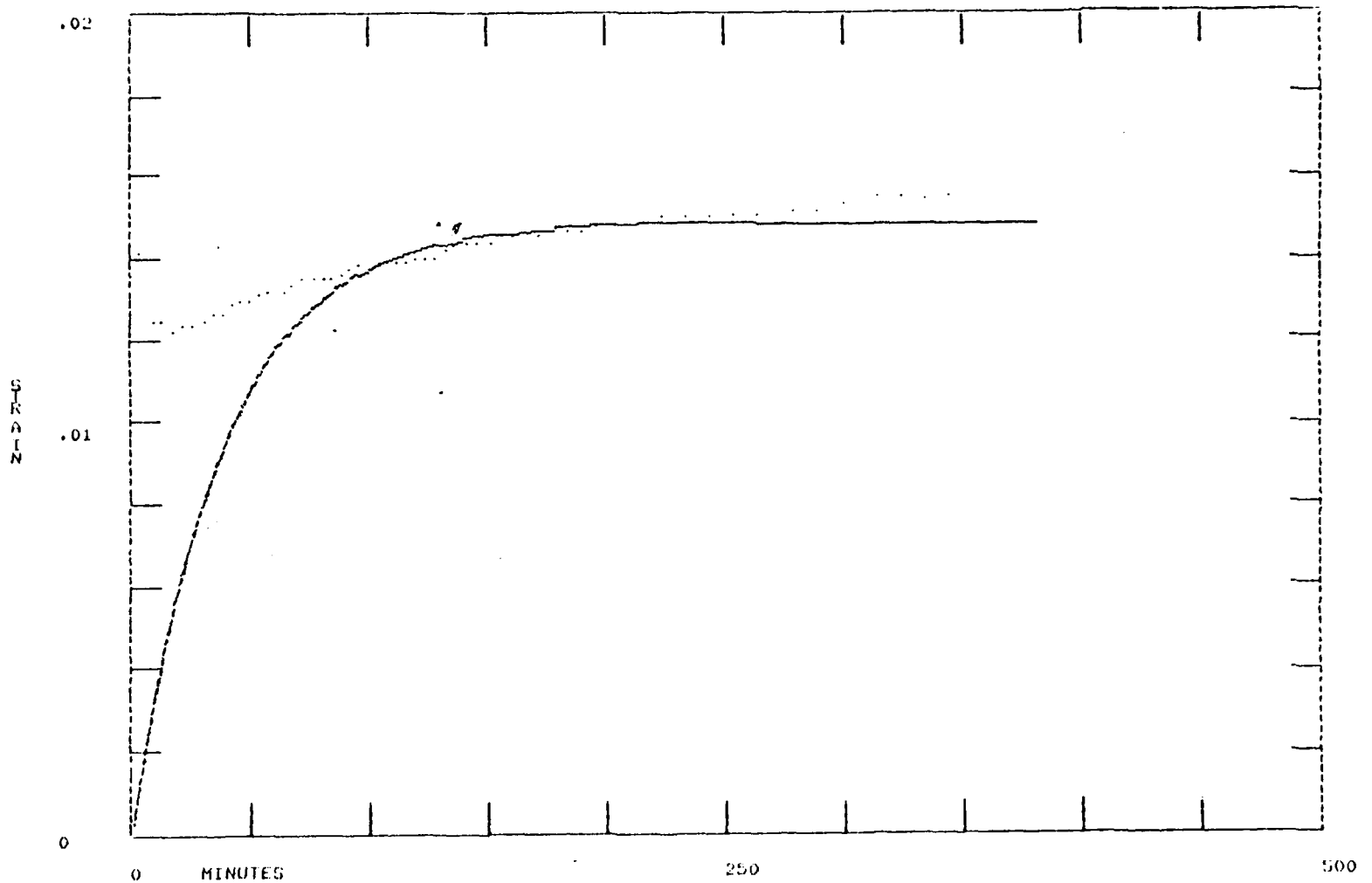
LK-47 T11-T12 04 FEB 75 AREA = 19.35 SQ CM HEIGHT = 2.789 CM
DOTTED LINE: ORIGINAL DATA HEAVY LINE: MODEL PREDICTION



4-PARAMETER SOLID MODEL WITH VALUES OF
A1 = 8.5873E-03, B1 = .045515, A2 = .015576, B2 = 6.8079E-03
DELTA TIME = 30
ERROR (USING ALL POINTS): 4.732%
ERROR (IGNORING FIRST 3 POINTS): 3.186%

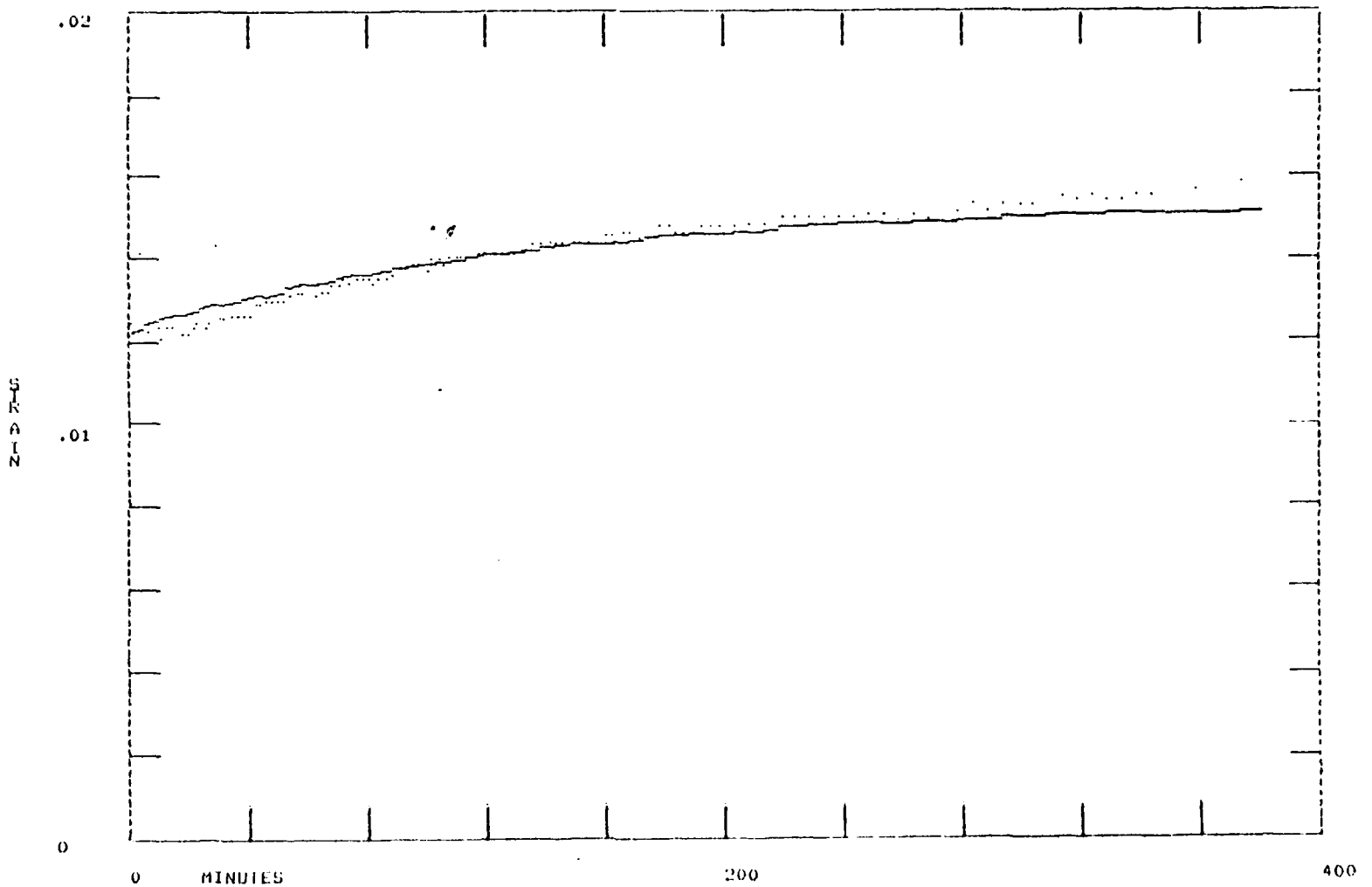
LR-47 111 112 04 FEB 75 AREA = 19.35 SQ CM HEIGHT = 2.709 CM
DOTTED LINE: ORIGINAL DATA HEAVY LINE: MODEL PREDICTION

87



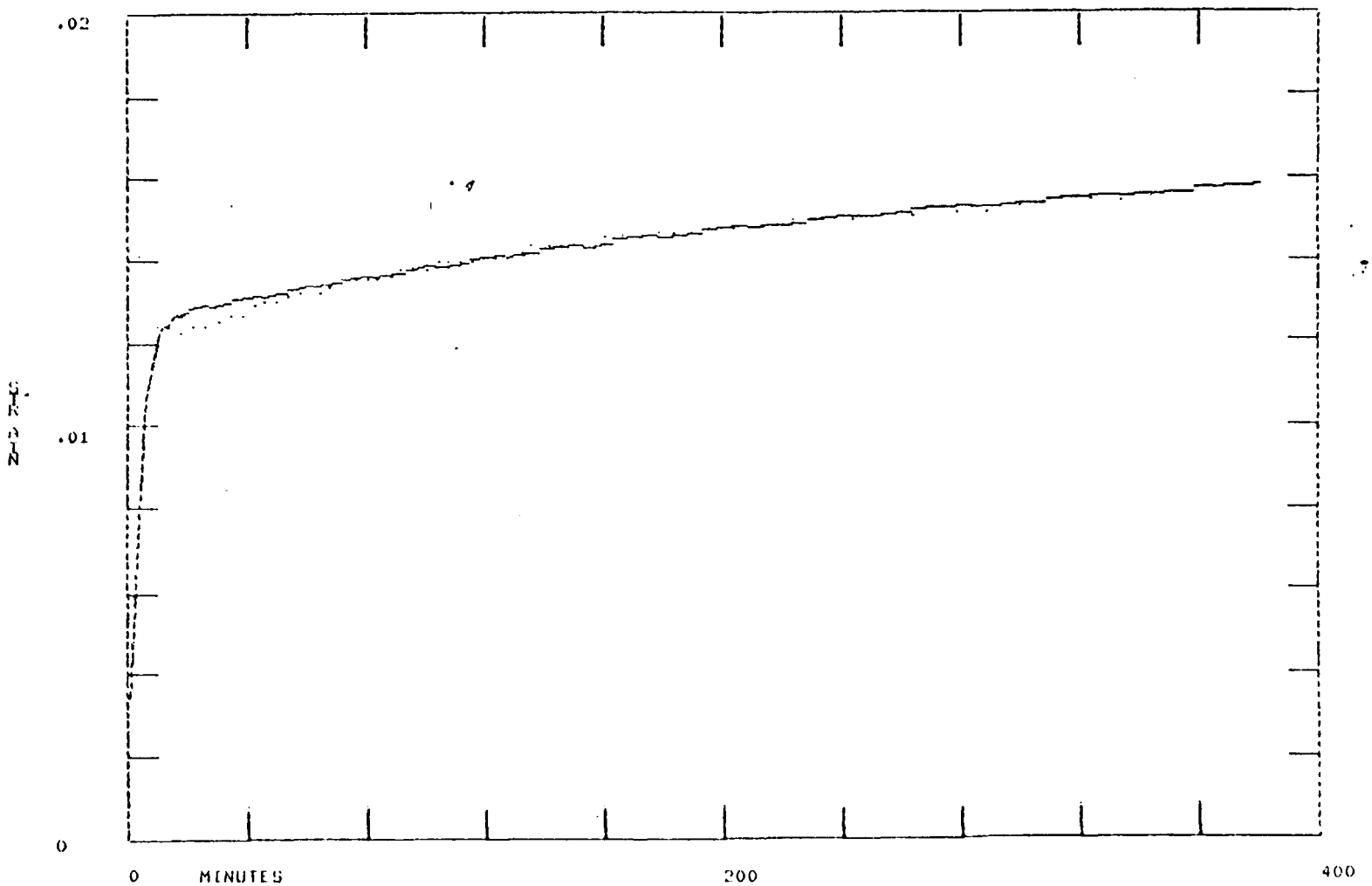
2-PARAMETER SOLID MODEL WITH VALUES OF
A1 = .014856 B1 = .026165
DELTA TIME = 16
ERROR (USING ALL POINTS): 10.652%
ERROR (IGNORING FIRST 3 POINTS): 7.323%

LN-48 T12-L1 5 FEB 75 AREA = 24.10 SQ CM HEIGHT = 2.34 CM
DOTTED LINE: ORIGINAL DATA HEAVY LINE: MODEL PREDICTION



3-PARAMETER SOLID MODEL WITH VALUES OF
A1 = .015511, E1 = 7.3452E-05, A2 = .012329
DELTA TIME = 4
ERROR (USING ALL POINTS): 0.832%
ERROR (IGNORING FIRST 3 POINTS): 0.312%

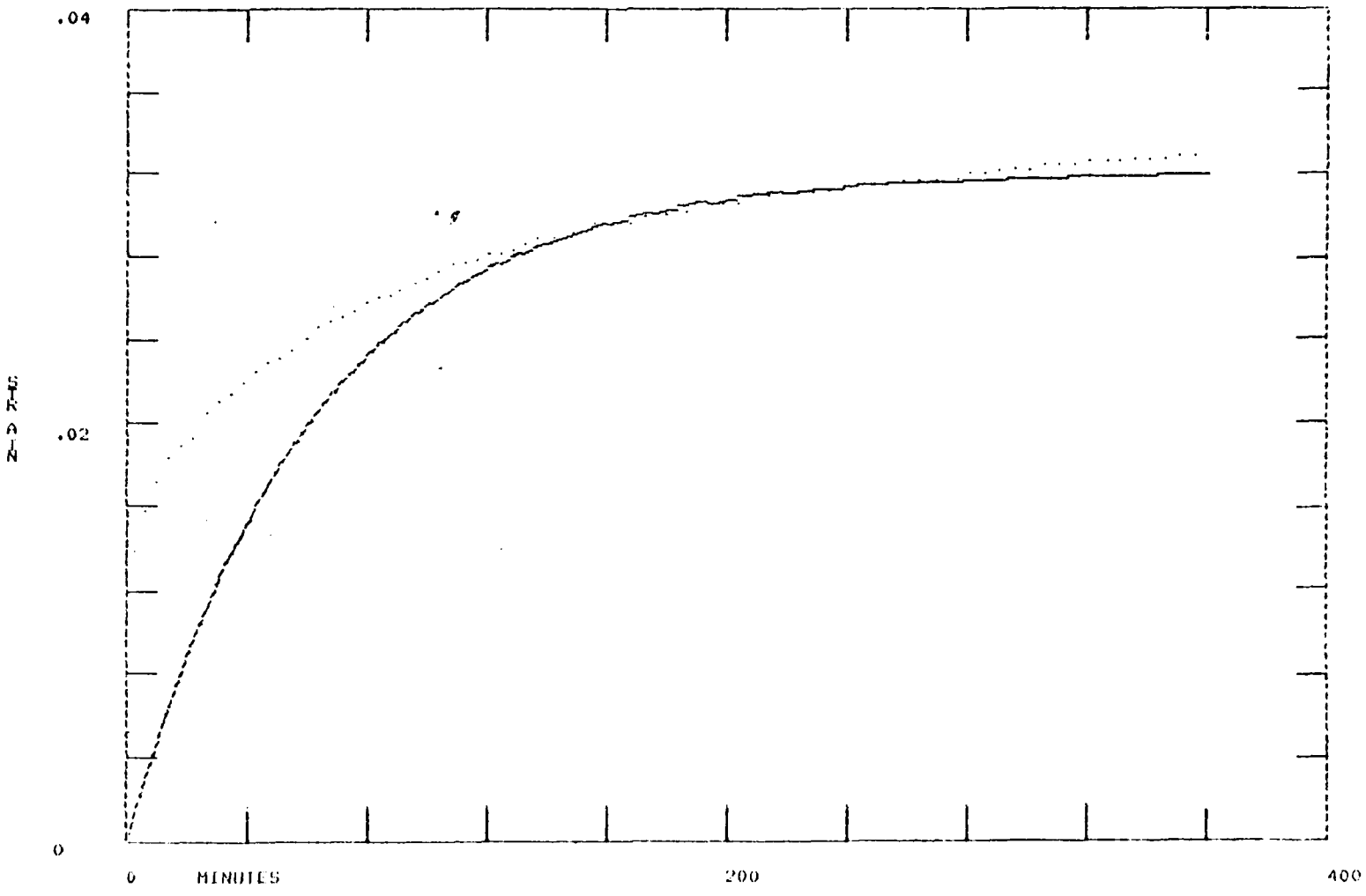
LK-40 T12-11 5 FEB 75 AREA = 24.10 SQ CM HEIGHT = 2.34 CM
DOTTED LINE: ORIGINAL DATA HEAVY LINE: MODEL PREDICTION



4-PARAMETER SOLID MODEL WITH VALUES OF
A1 = .012508, B1 = .31876, A2 = 4.3489E-03, B2 = 3.6555E-03
DELTA TIME = 16
ERROR (USING ALL POINTS): 1.254%
ERROR (IGNORING FIRST 3 POINTS): -0.428%

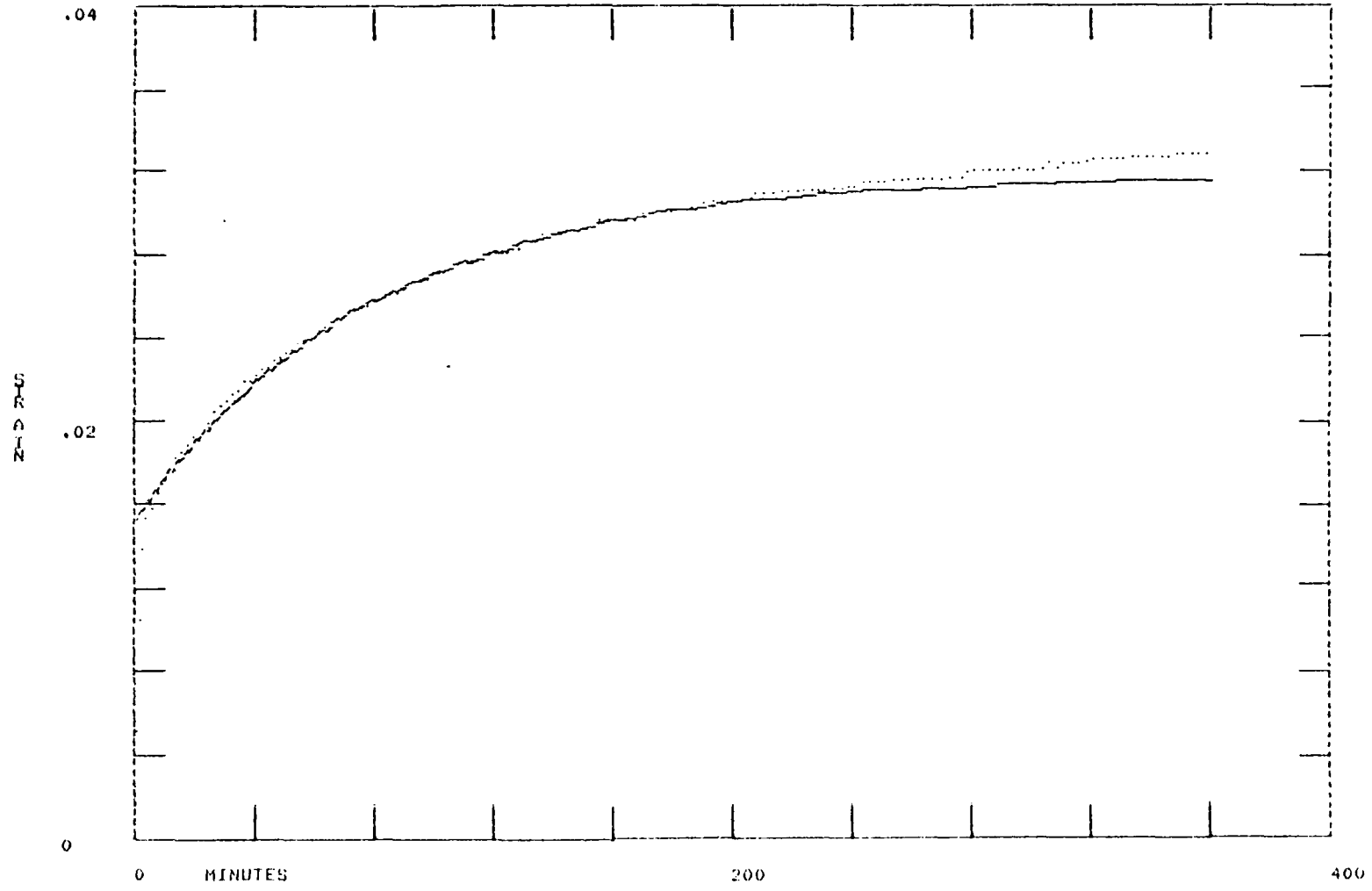
90

LN-48 T12-L1 5 FEB 75 AREA = 24.18 SQ CM HEIGHT = 2.34 CM
DOTTED LINE: ORIGINAL DATA HEAVY LINE: MODEL PREDICTION



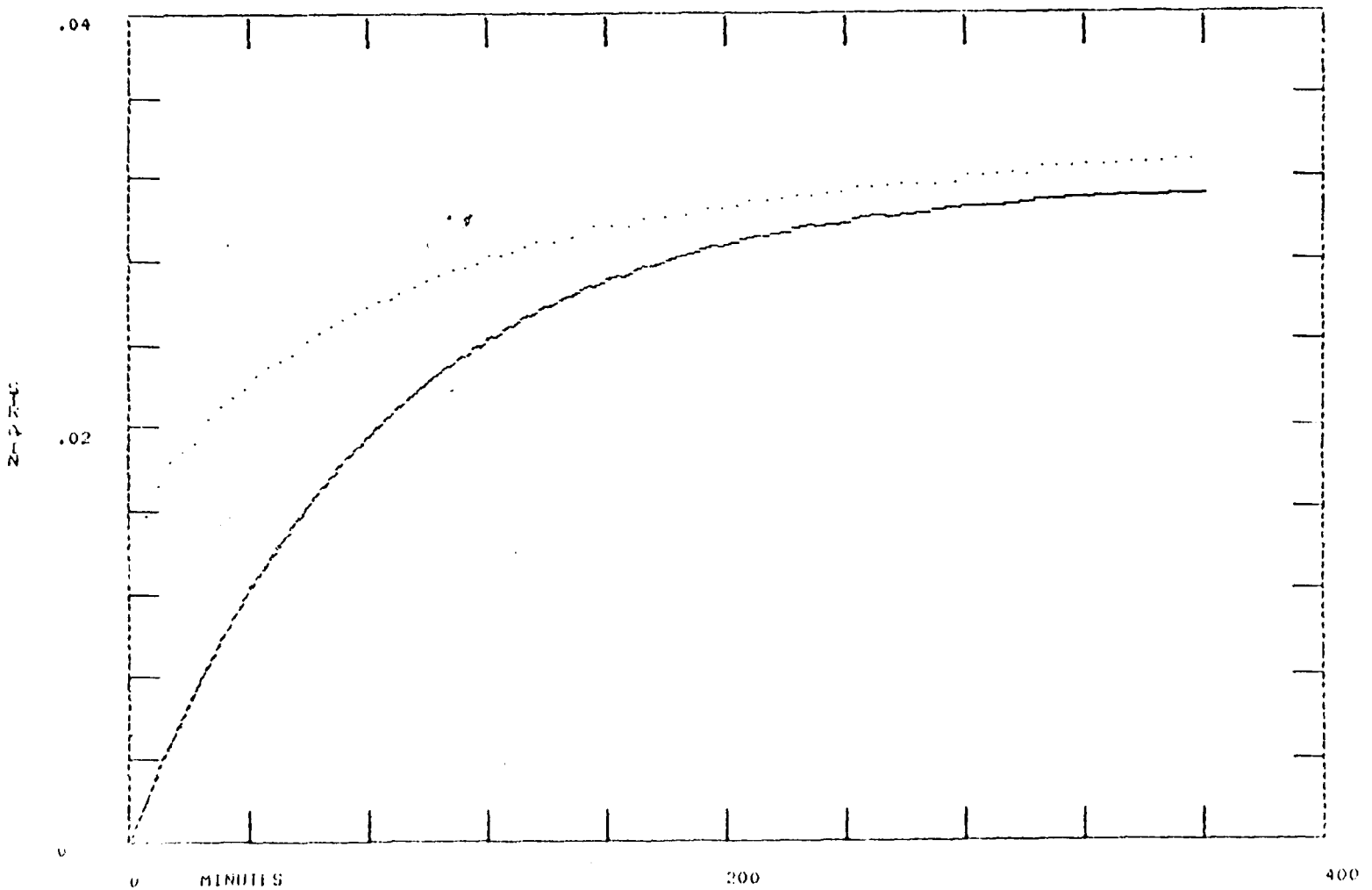
2-PARAMETER SOLID MODEL WITH VALUES OF
A1 = .0532037, B1 = .0162227
DELTA TIME = 16
ERROR (USING ALL POINTS): 8.211%
ERROR (IGNORING FIRST 3 POINTS): 6.896%

LN-49 19-T10 6 FEB 75 AREA = 19.99 50 CM HEIGHT = 2.171 CM
DOTTED LINE: ORIGINAL DATA HEAVY LINE: MODEL PREDICTION



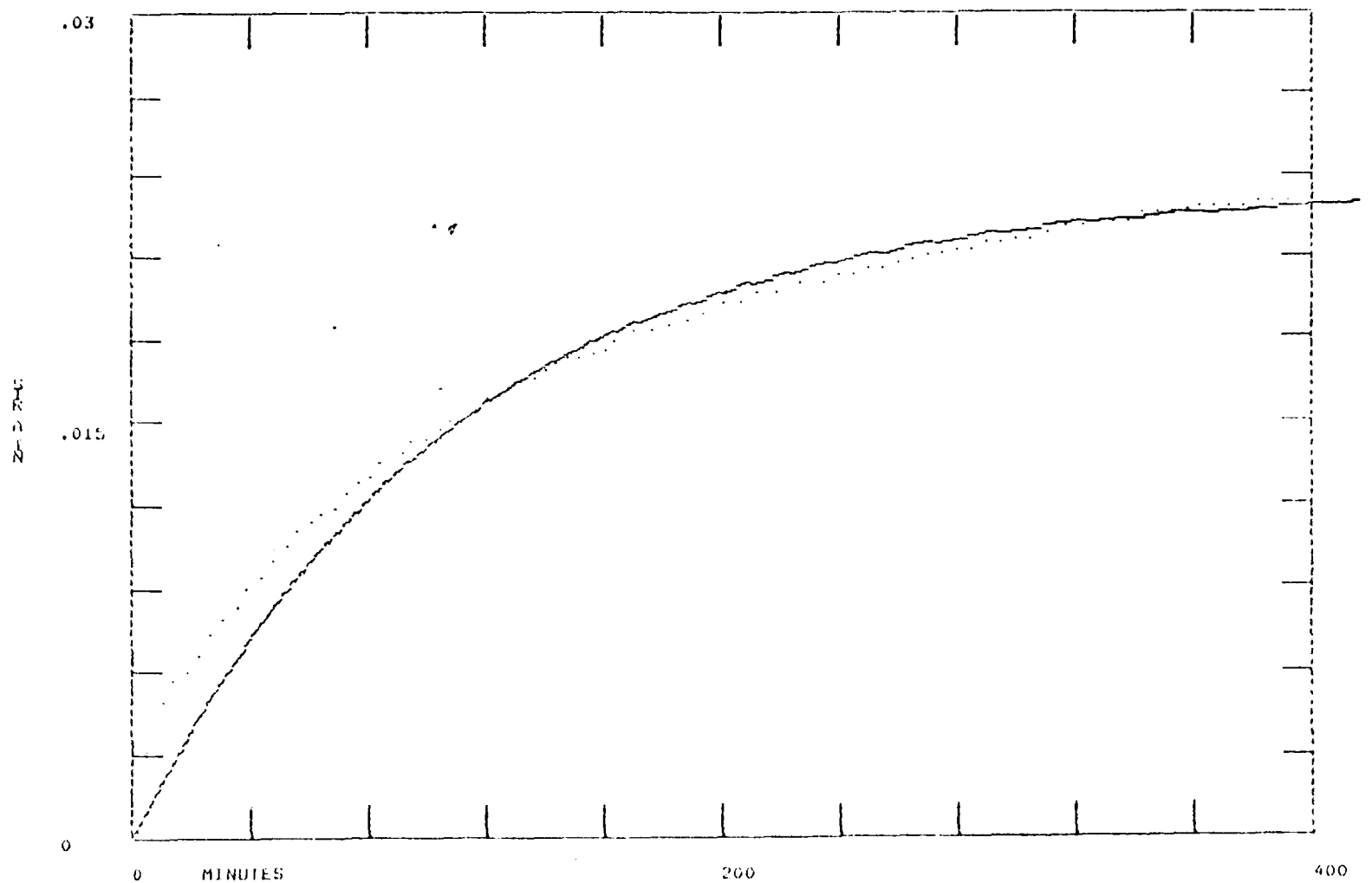
3-PARAMETER SOLID MODEL WITH VALUES OF
A1 = .031772, B1 = .012225, A2 = .015214
DELTA TIME = 4
ERROR (USING ALL POINTS): 0.847%
ERROR (IGNORING FIRST 3 POINTS): 1.203%

LR-49 T9-T10 6 FEB 75 AREA = 19.99 SQ CM HEIGHT = 2.171 CM
DOTTED LINE: ORIGINAL DATA HEAVY LINE: MODEL PREDICTION



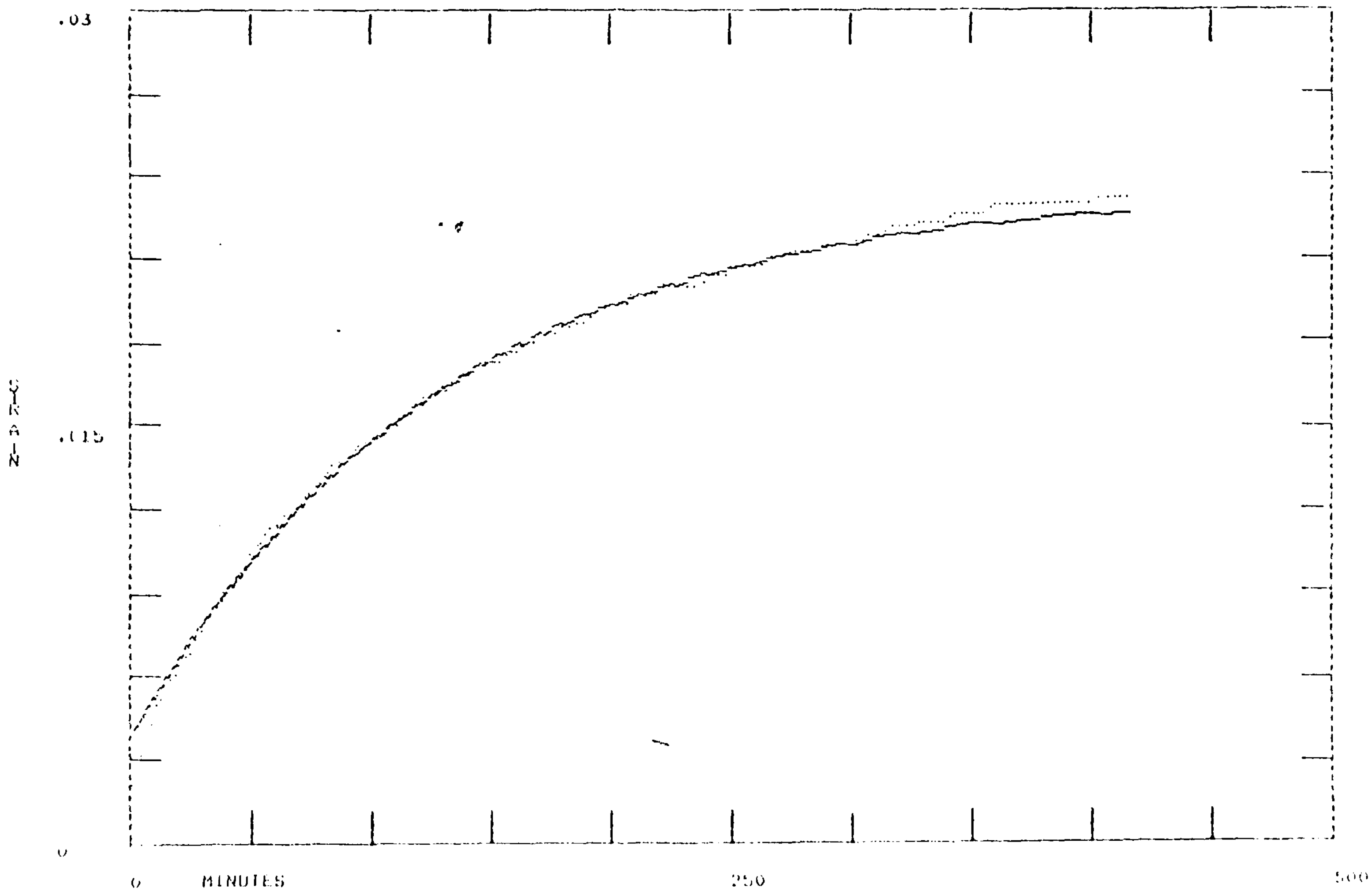
4-PARAMETER SOLID MODEL WITH VALUES OF
A1 = .014043, B1 = .0108, A2 = .012681, B2 = .013027
DELTA TIME = 8
ERROR (USING ALL POINTS): 15.913%
ERROR (IGNORING FIRST 3 POINTS): 14.666%

IK 49 12 110 6 FEB 75 AREA = 19.99 SQ CM HEIGHT = 2.171 CM
DOTTED LINE: ORIGINAL DATA HEAVY LINE: MODEL PREDICTION



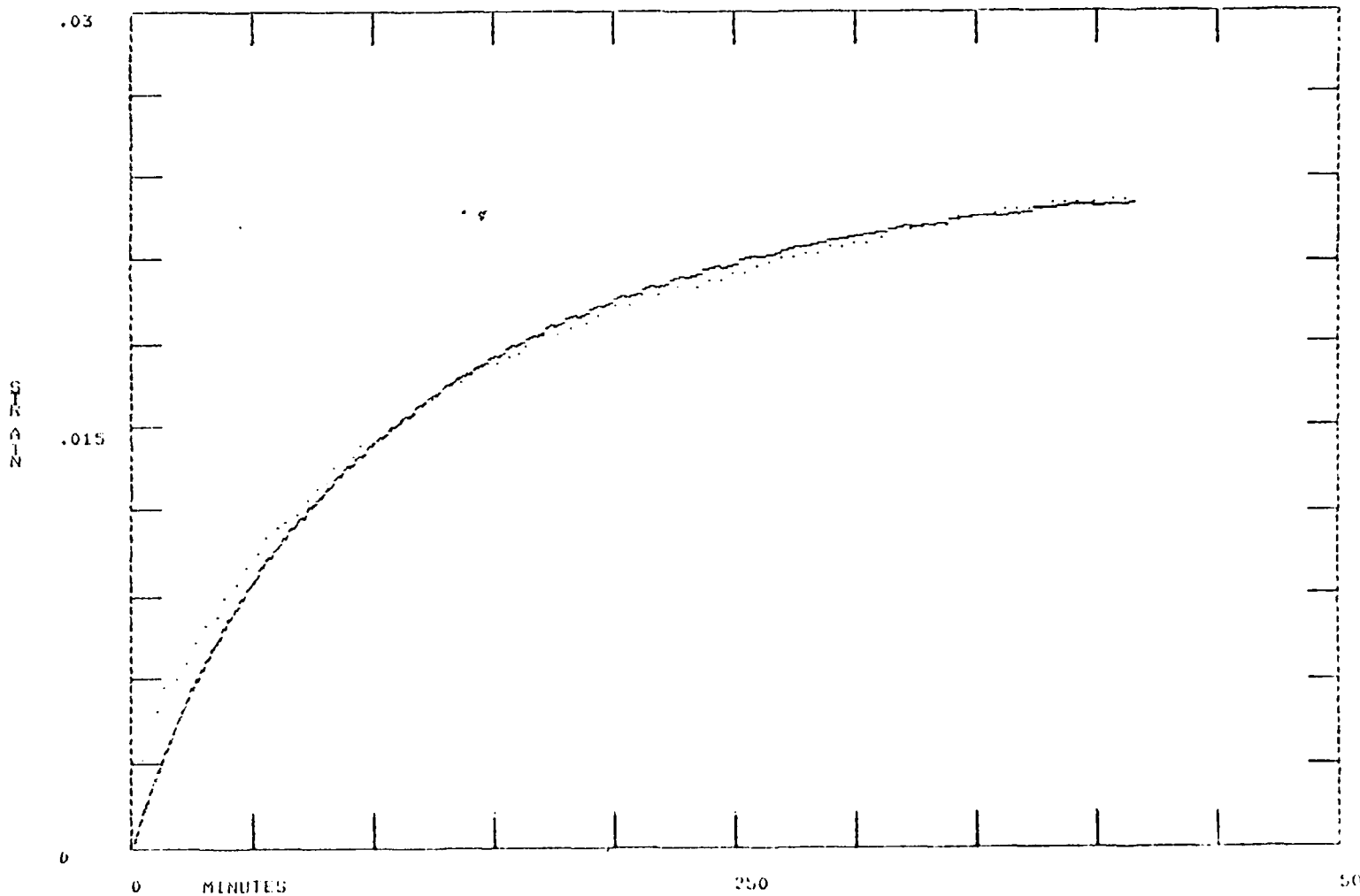
2-PARAMETER SOLID MODEL WITH VALUES OF
AL = .0225445, BL = 9.23564E-05
DELTA TIME = 30
ERROR (USING ALL POINTS): 1.922%
ERROR (IGNORING FIRST 3 POINTS): 1.540%

11:50 TUE 7 FEB 75 AREA = 10.26 SQ CM HEIGHT = 2.10 CM
DOTTED LINE: ORIGINAL DATA HEAVY LINE: MODEL PREDICTION



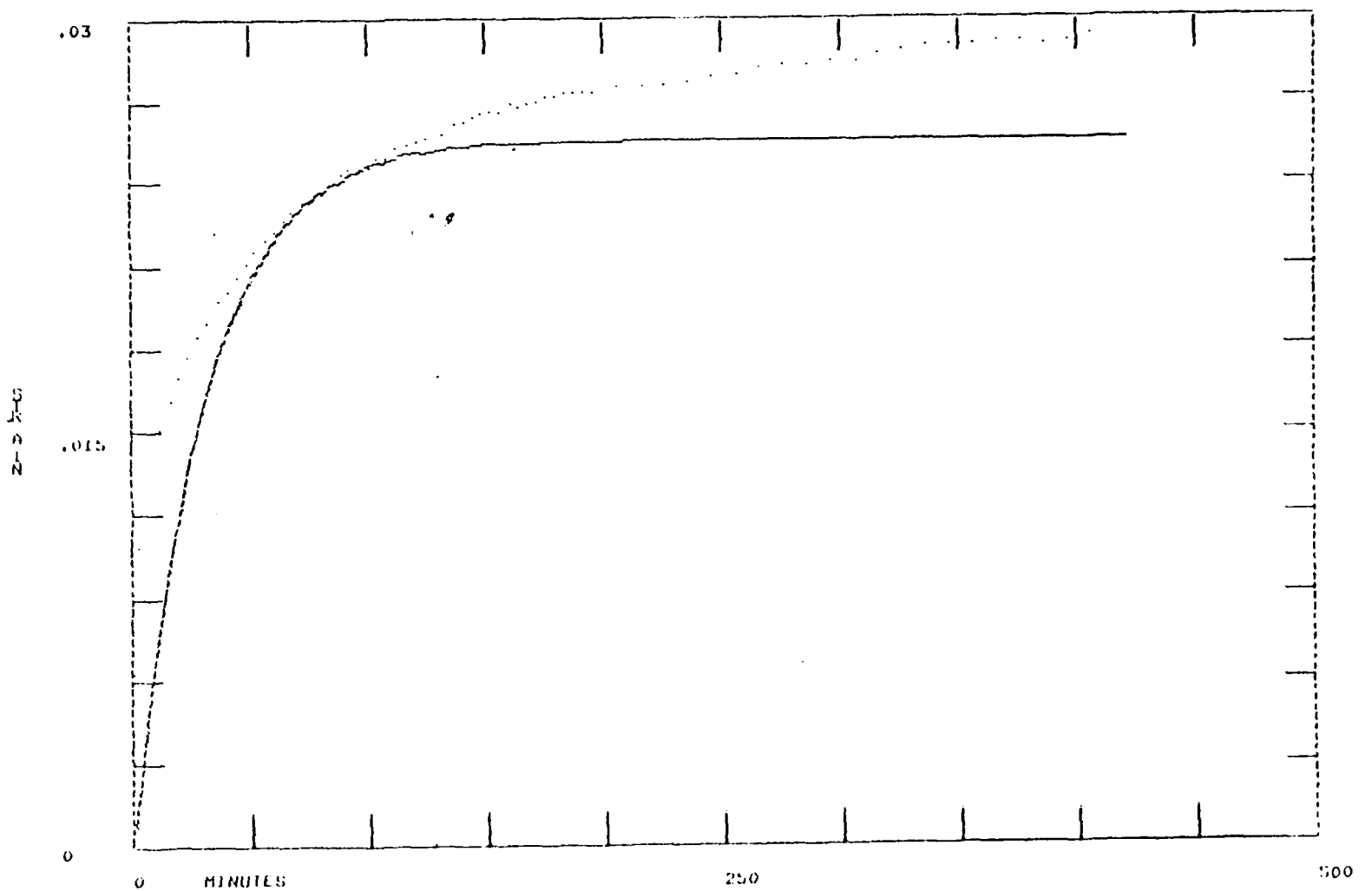
3 PARAMETER SOLID MODEL WITH VALUES OF
[illegible] = .0[illegible]885, [illegible] = 7.2698E-03, [illegible] = 3.[illegible]E-03
[illegible] TIME = 16
ERROR (USING ALL POINTS): [illegible]%
ERROR (IGNORING FIRST 3 POINTS): 0.[illegible]%

ID 50 [illegible] 7 FEB 75 AREA = 10.26 SQ CM HEIGHT = 2.10 CM
DOTTED LINE: ORIGINAL DATA HEAVY LINE: MODEL PREDICTION



4-PARAMETER SOLID MODEL WITH VALUES OF
A1 = 3.85222E-03, B1 = .0353272, A2 = .0220125, B2 = 7.5746E-03
DELTA TIME = 8
ERROR (USING ALL POINTS): 1.1255%
ERROR (IGNORING FIRST 3 POINTS): 0.756%

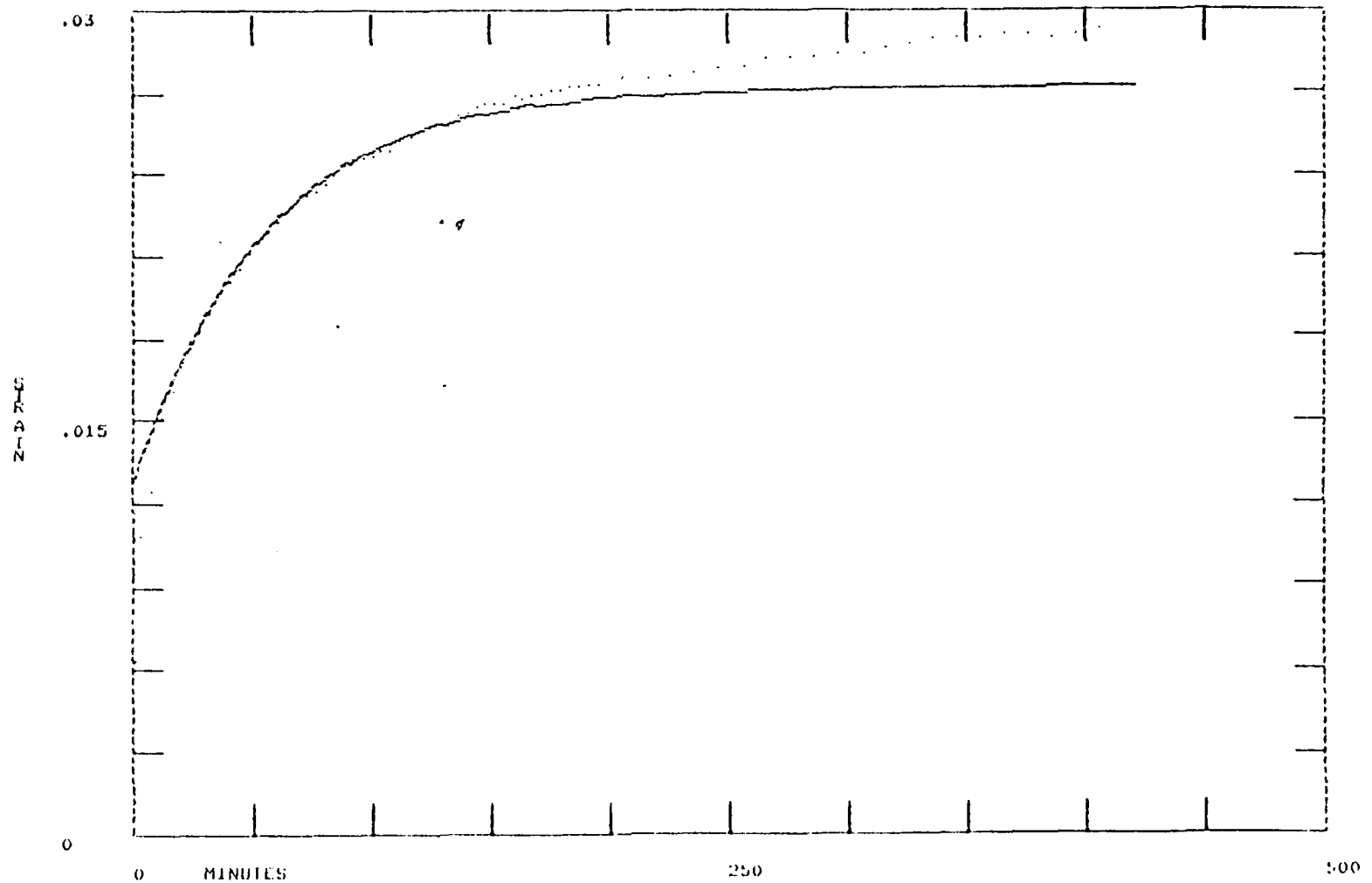
LN-50 T10-T11 7 FEB 75 AREA = 10.26 SQ CM HEIGHT = 2.10 CM
DOTTED LINE: ORIGINAL DATA HEAVY LINE: MODEL PREDICTION



2-PARAMETER SOLID MODEL WITH VALUES OF
A1 = .0225648, B1 = .0322335

DELTA TIME = 8
ERROR (USING ALL POINTS): 6.886%
ERROR (IGNORING FIRST 3 POINTS): 5.289%

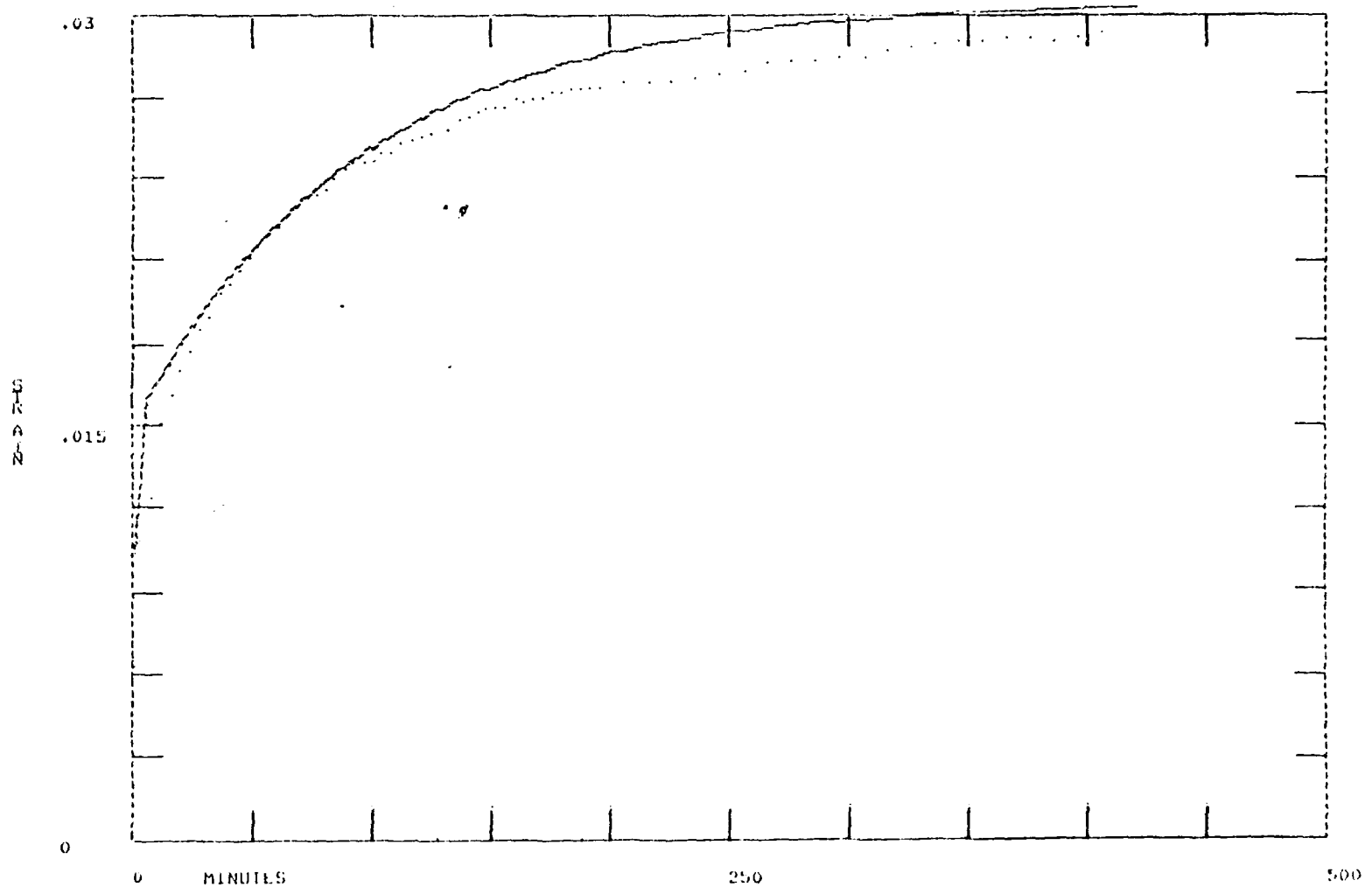
LN-51 18-19 10 FEB 75 AREA = 17.11 SQ CM HEIGHT = 2.163 CM
DOTTED LINE: ORIGINAL DATA HEAVY LINE: MODEL PREDICTION



3-PARAMETER SOLID MODEL WITH VALUES OF
A1 = .022254, B1 = .018004, A2 = .012833
DELTA TIME = 30
ERROR (USING ALL POINTS): -0.059%
ERROR (IGNORING FIRST 3 POINTS): 0.599%

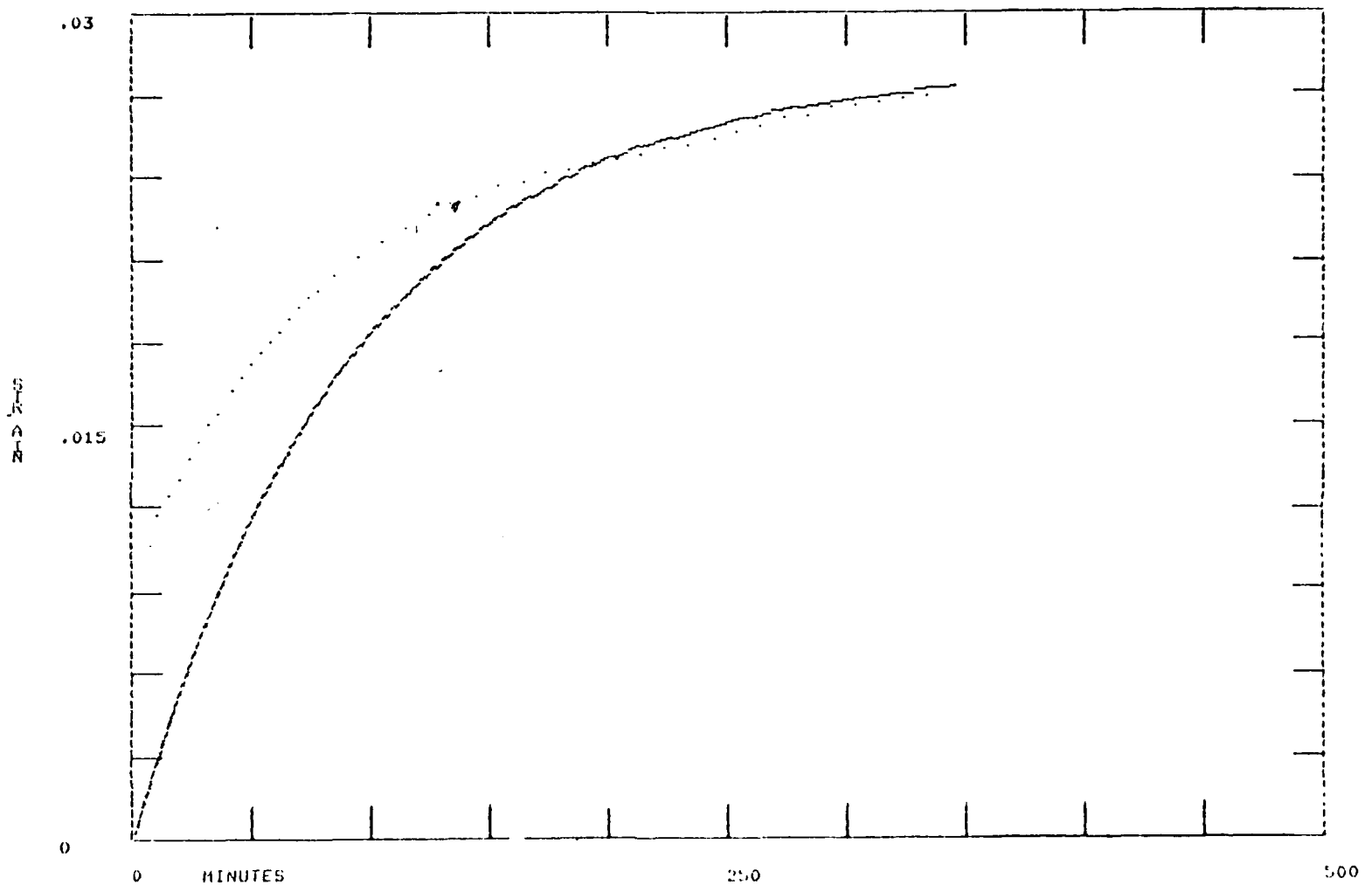
LR 51 TO 19 10 FEB 75 AREA = 17.11 SQ CM HEIGHT = 2.163 CM
DOTTED LINE: ORIGINAL DATA HEAVY LINE: MODEL PREDICTION

-14-



4-PARAMETER SOLID MODEL WITH VALUES OF
A1 = .013026, B1 = 1.1736, A2 = .0155, B2 = .010662
DELTA TIME = 4
ERROR (USING ALL POINTS): -5.243%
ERROR (IGNORING FIRST 3 POINTS): -4.651%

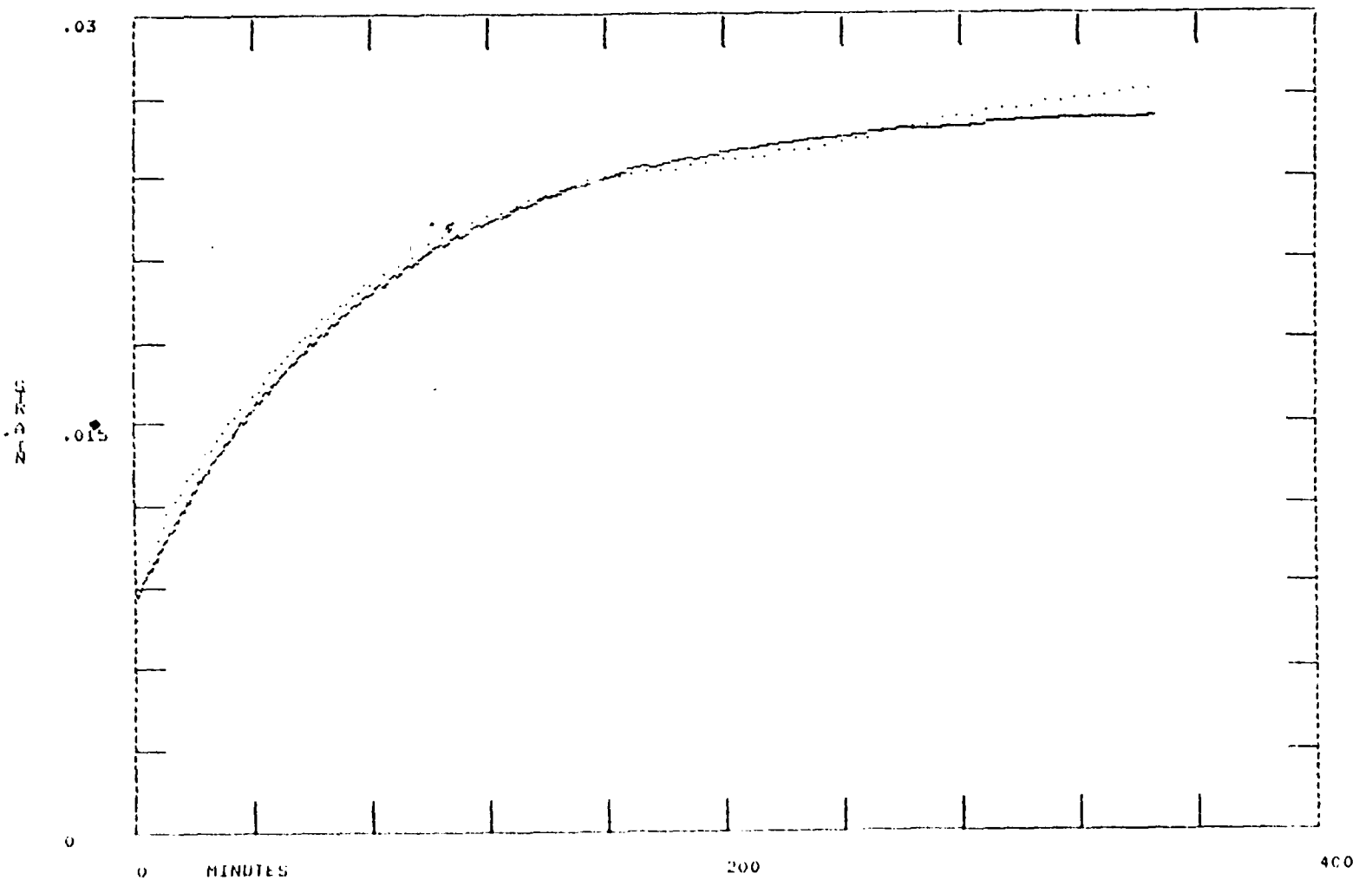
EX 51 TB 19 10 FEB 75 AREA = 17.11 SQ CM HEIGHT = 2.163 CM
DOTTED LINE: ORIGINAL DATA HEAVY LINE: MODEL PREDICTION



2-PARAMETER SOLID MODEL WITH VALUES OF
A1 = .022949, B1 = .010751

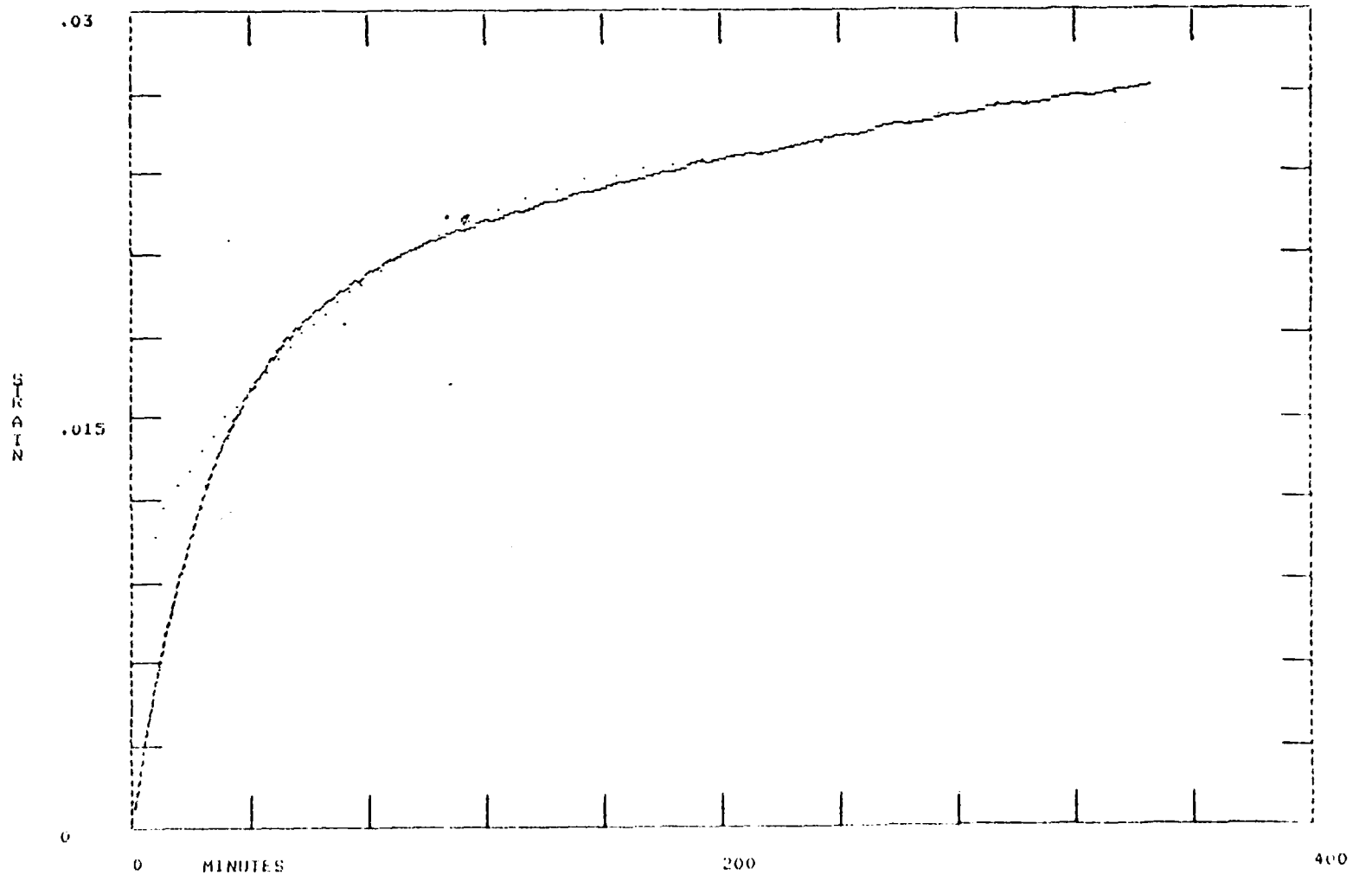
DELTA TIME = 30
ERROR (USING ALL POINTS): 14.779%
ERROR (IGNORING FIRST 3 POINTS): 12.848%

LA-52 T7-T8 11 FEB 75 AREA = 16.21 SQ CM HEIGHT = 2.64 CM
DOTTED LINE: ORIGINAL DATA HEAVY LINE: MODEL PREDICTION



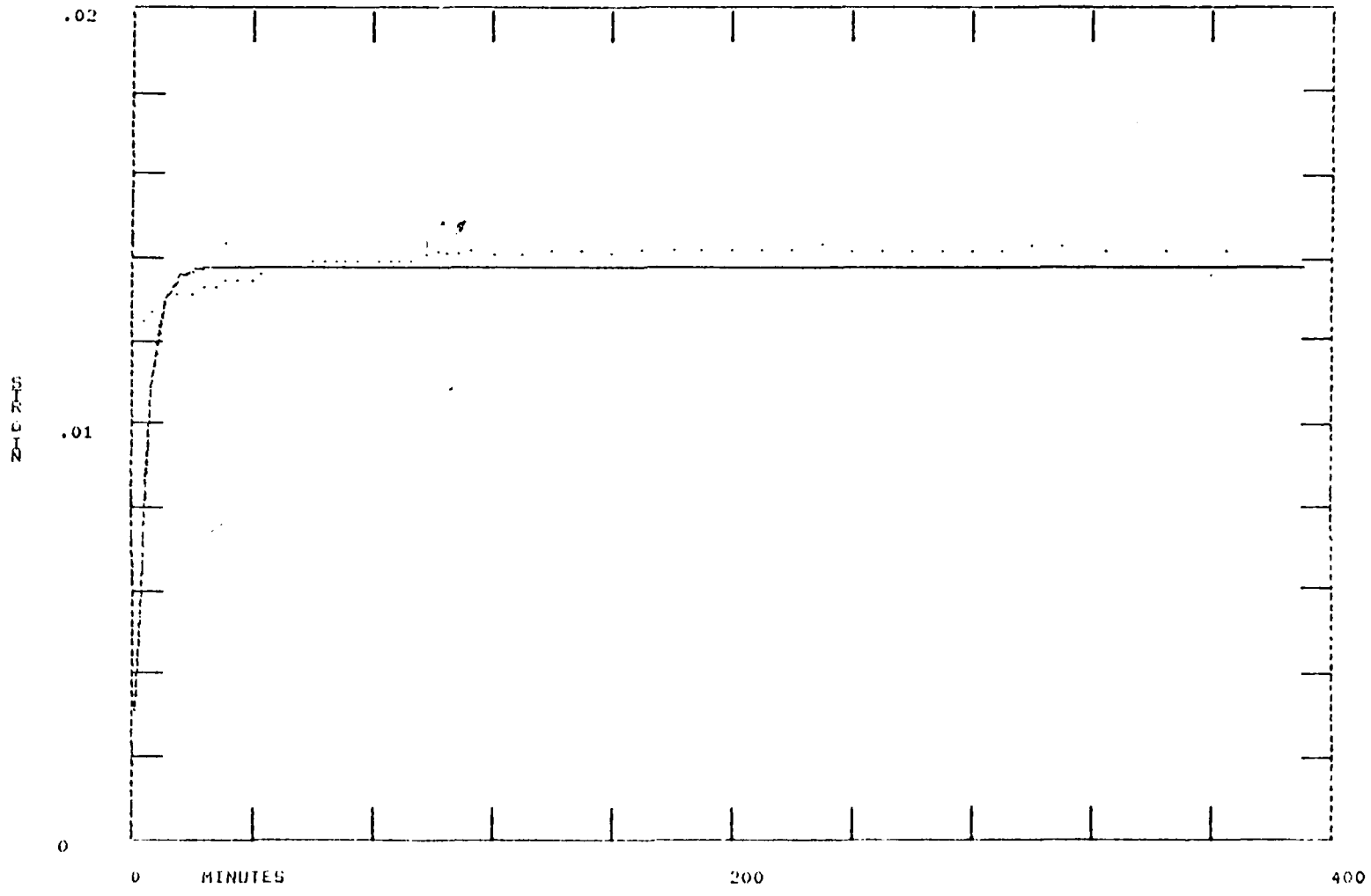
3-PARAMETER SOLID MODEL WITH VALUES OF
A1 = .0226559, B1 = .012218, A2 = .008561
DELTA TIME = 30
ERROR (USING ALL POINTS): 1.282%
ERROR (IGNORING FIRST 3 POINTS): 1.529%

IN 52 17 10 11 FEB 75 AREA = 16.21 SQ CM HEIGHT = 2.645 CM
DOTTED LINE: ORIGINAL DATA HEAVY LINE: MODEL PREDICTION



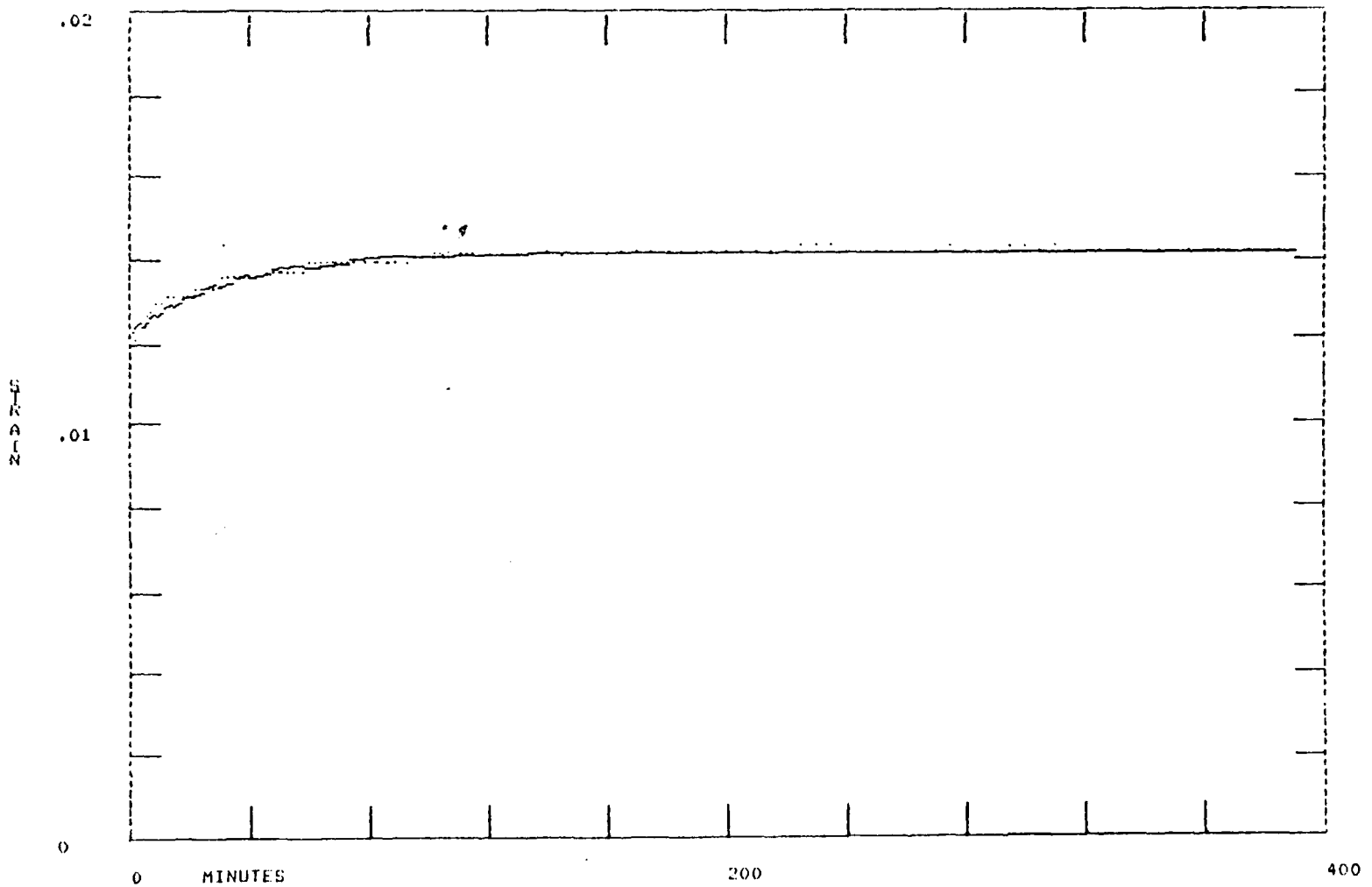
4-PARAMETER SOLID MODEL WITH VALUES OF
A1 = .012932, B1 = .039958, A2 = .0141, B2 = 3.122E-03
DELTA TIME = 8
ERROR (USING ALL POINTS): 3.592%
ERROR (IGNORING FIRST 3 POINTS): 1.770%

LK-52 17:10 11 FEB 75 AREA = 16.21 SQ CM HEIGHT = 2.645 CM
DOTTED LINE: ORIGINAL DATA HEAVY LINE: MODEL PREDICTION



2-PARAMETER SOLID MODEL WITH VALUES OF
A1 = .013834, B1 = .25824
DELTA TIME = 8
ERROR (USING ALL POINTS): 35.013%
ERROR (IGNORING FIRST 3 POINTS): 1.299%

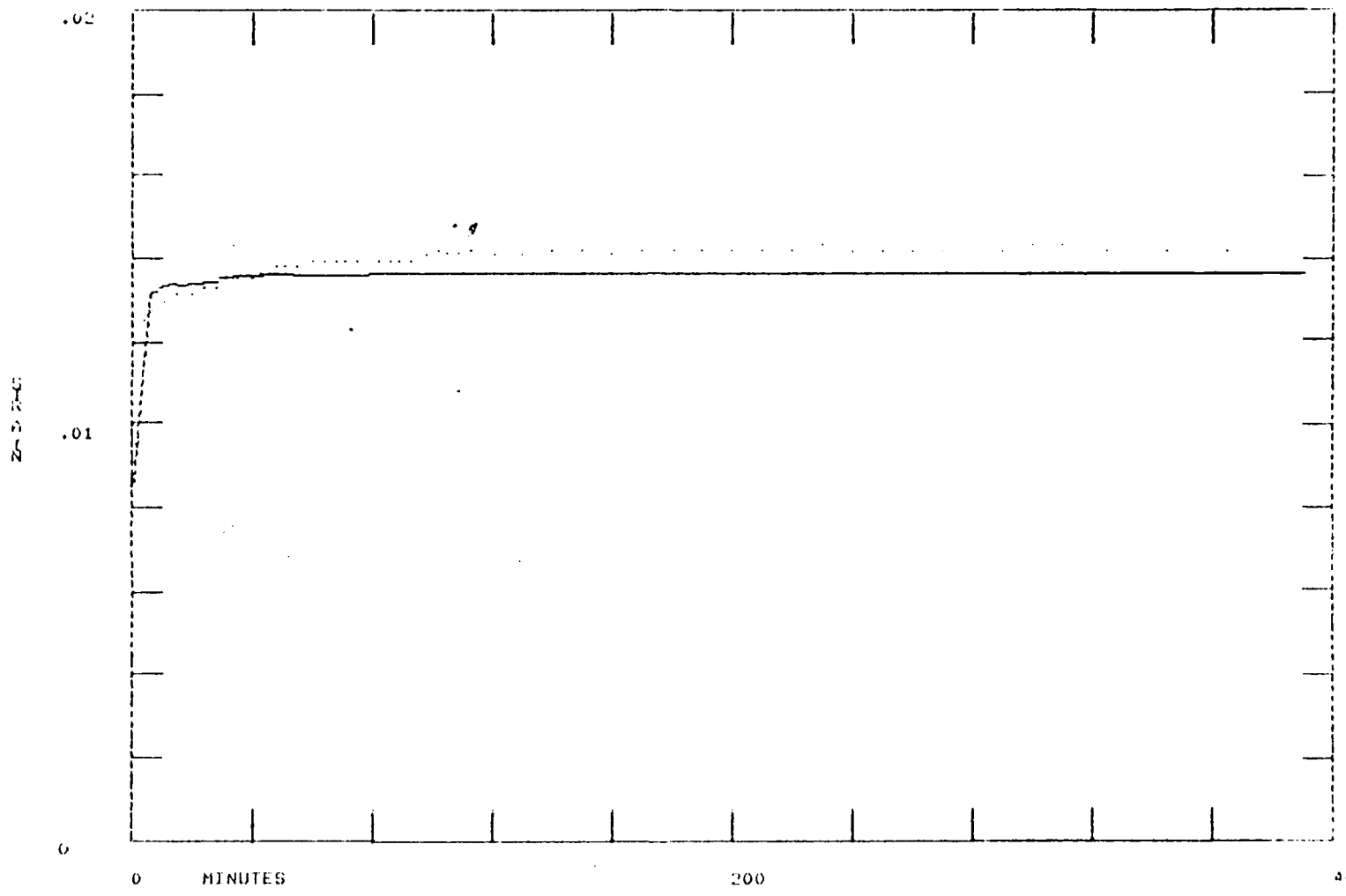
LN-53 14-15 12 FEB 75 AREA = 14.03 SQ CM HEIGHT = 1.965 CM
DOTTED LINE: ORIGINAL DATA HEAVY LINE: MODEL PREDICTION



3-PARAMETER SOLID MODEL WITH VALUES OF
A1 = .014237, B1 = .030002, A2 = .012228
DELTA TIME = 4
ERROR (USING ALL POINTS): 0.612%
ERROR (IGNORING FIRST 3 POINTS): 0.073%

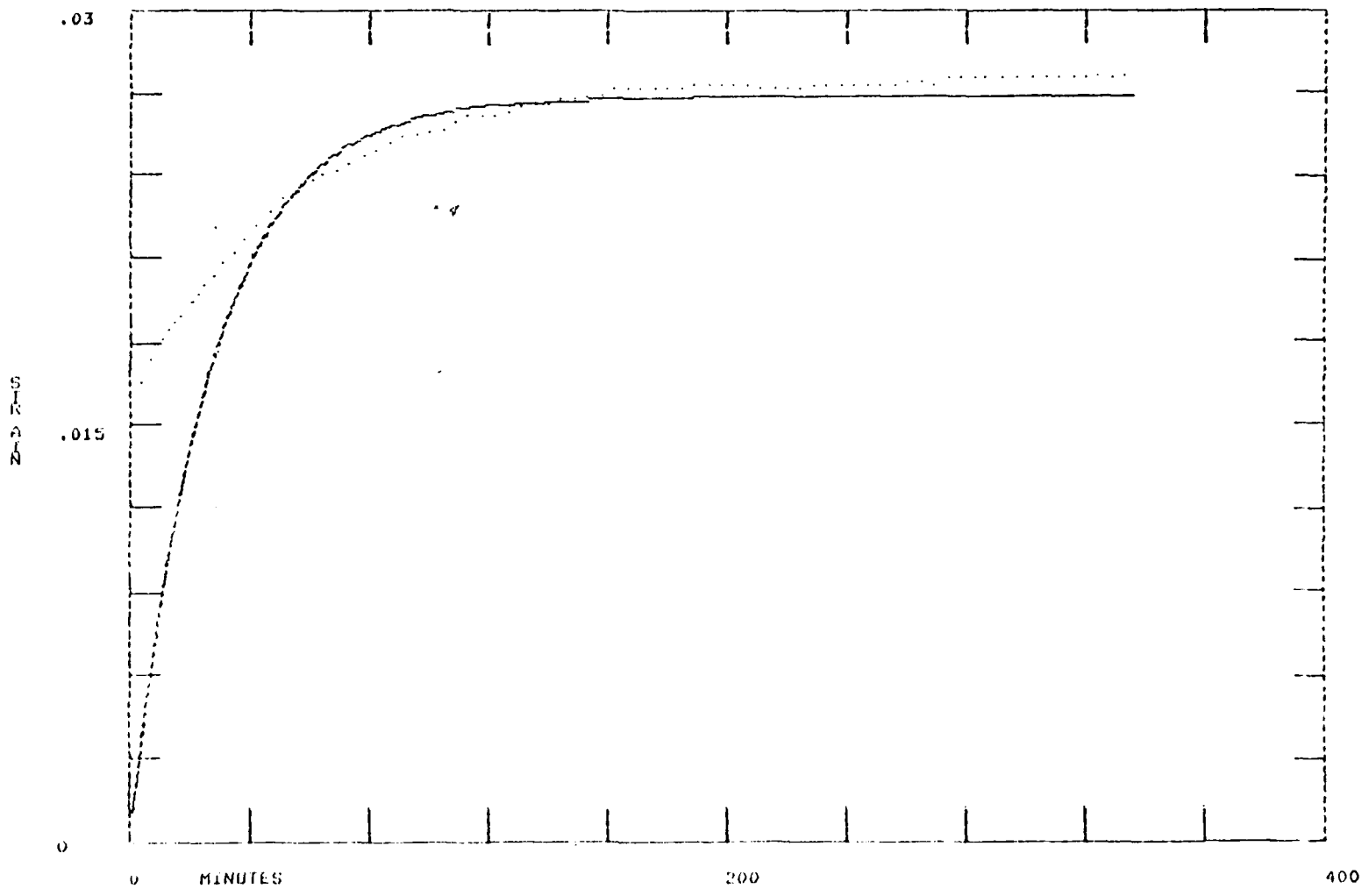
LN-53 14-15 12 FEB 75 AREA = 14.03 SQ CM HEIGHT = 1.965 CM
DOTTED LINE: ORIGINAL DATA HEAVY LINE: MODEL PREDICTION

114



4-PARAMETER SOLID MODEL WITH VALUES OF
A1 = 5.7302E-04, B1 = .0387, A2 = .013136, B2 = 1.0862
DELTA TIME = 4
ERROR (USING ALL POINTS): 3.224%
ERROR (IGNORING FIRST 3 POINTS): 2.379%

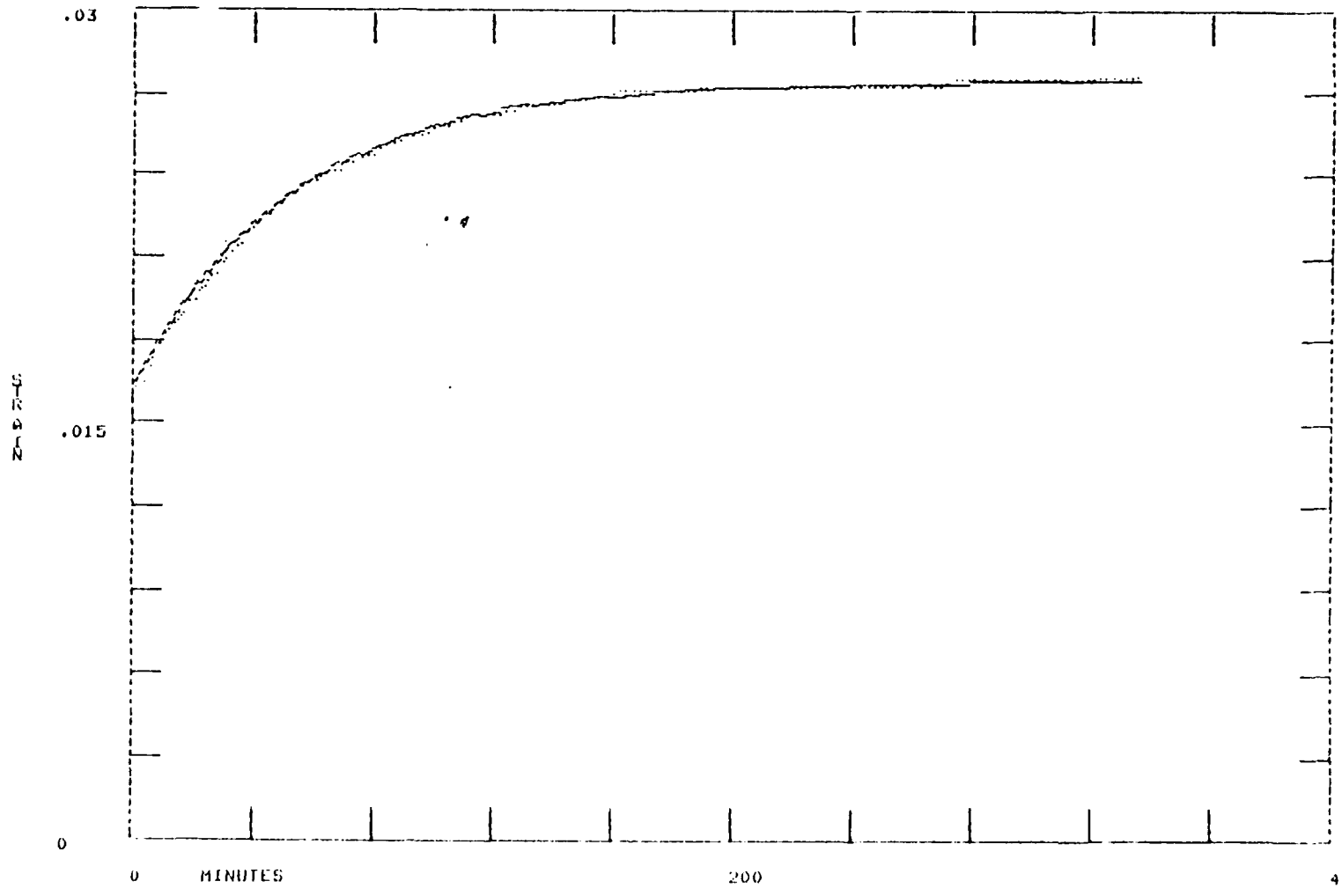
LN-53 T4-T5 12 FEB 75 AREA = 14.03 SQ CM HEIGHT = 1.965 CM
DOTTED LINE: ORIGINAL DATA HEAVY LINE: MODEL PREDICTION



2 PARAMETER SOLID MODEL WITH VALUES OF
A1 = .0226842 , B1 = .03763

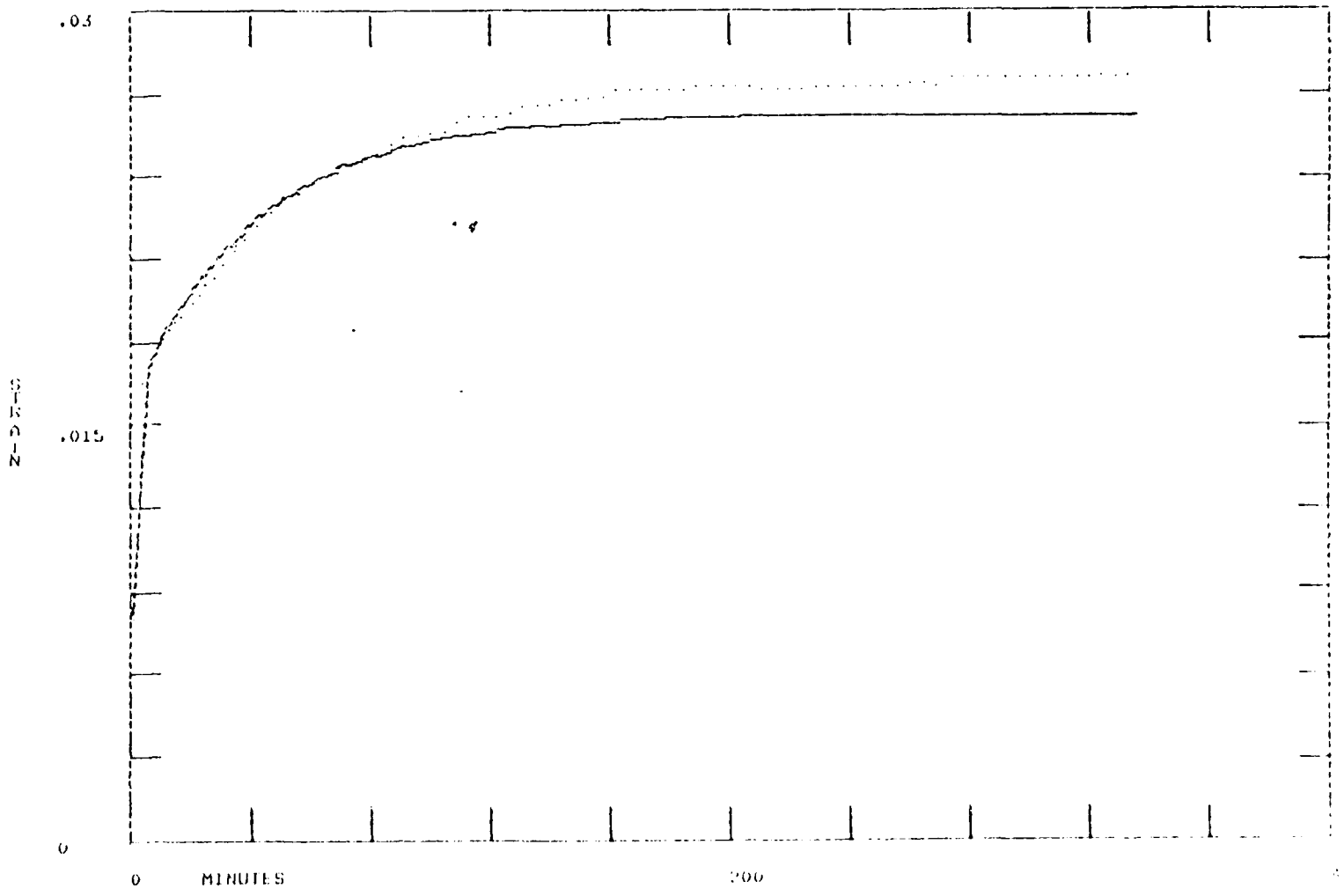
DELTA TIME = 8
ERROR <USING ALL POINTS> : 5.0432%
ERROR <IGNORING FIRST 3 POINTS> : 3.4795%

EX 54 16:17 19 FEB 75 AREA = 11.06 SQ CM HEIGHT = 2.6 CM
DOTTED LINE: ORIGINAL DATA HEAVY LINE: MODEL PREDICTION



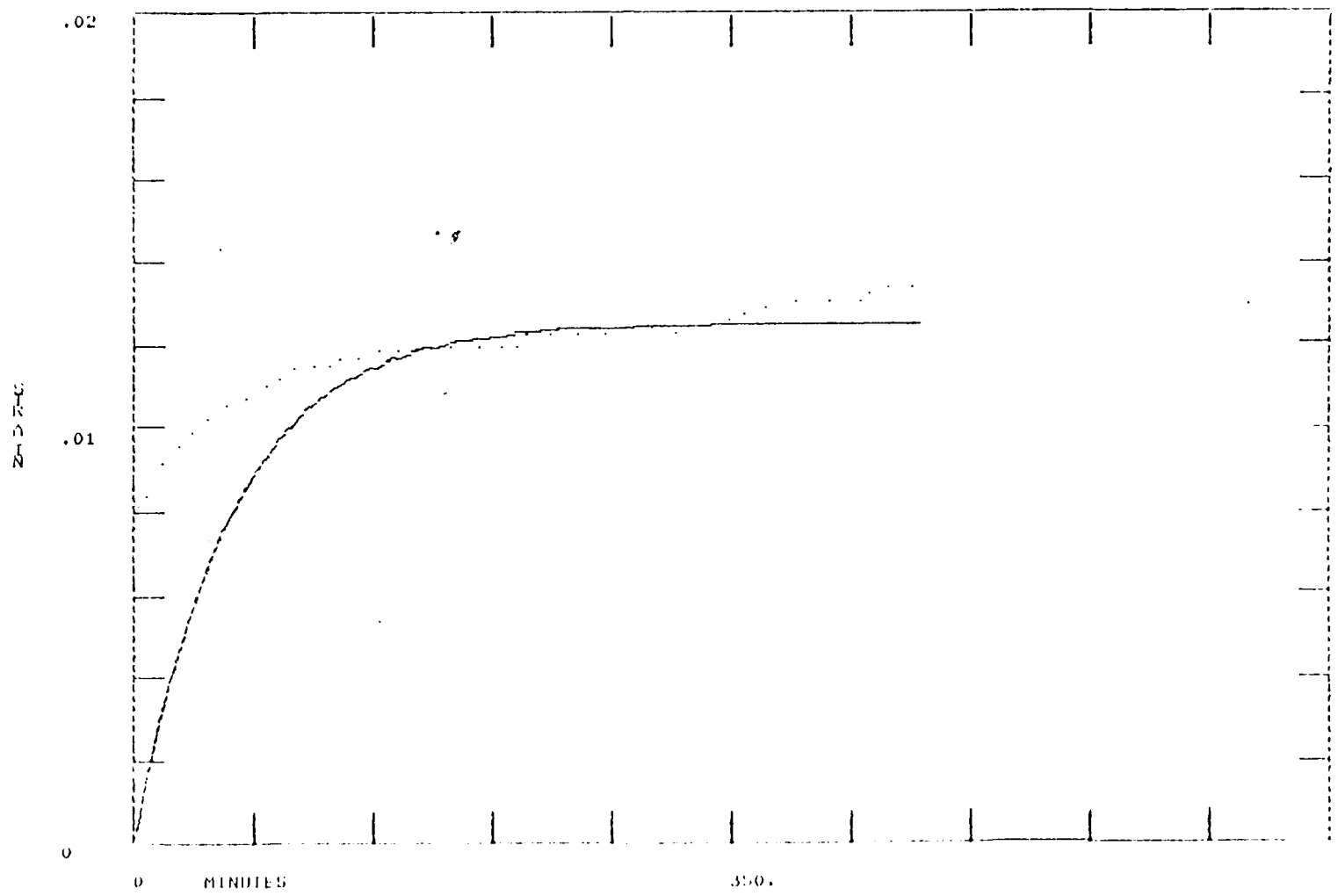
3-PARAMETER SOLID MODEL WITH VALUES OF
A1 = .022594, E1 = .01871, A2 = .016289
DELTA TIME = 4
ERROR (USING ALL POINTS): 0.352%
ERROR (IGNORING FIRST 3 POINTS): -0.261%

IK-54 16-17 19 FEB 75 AREA = 11.06 SQ CM HEIGHT = 2.6 CM
DOTTED LINE: ORIGINAL DATA HEAVY LINE: MODEL PREDICTION



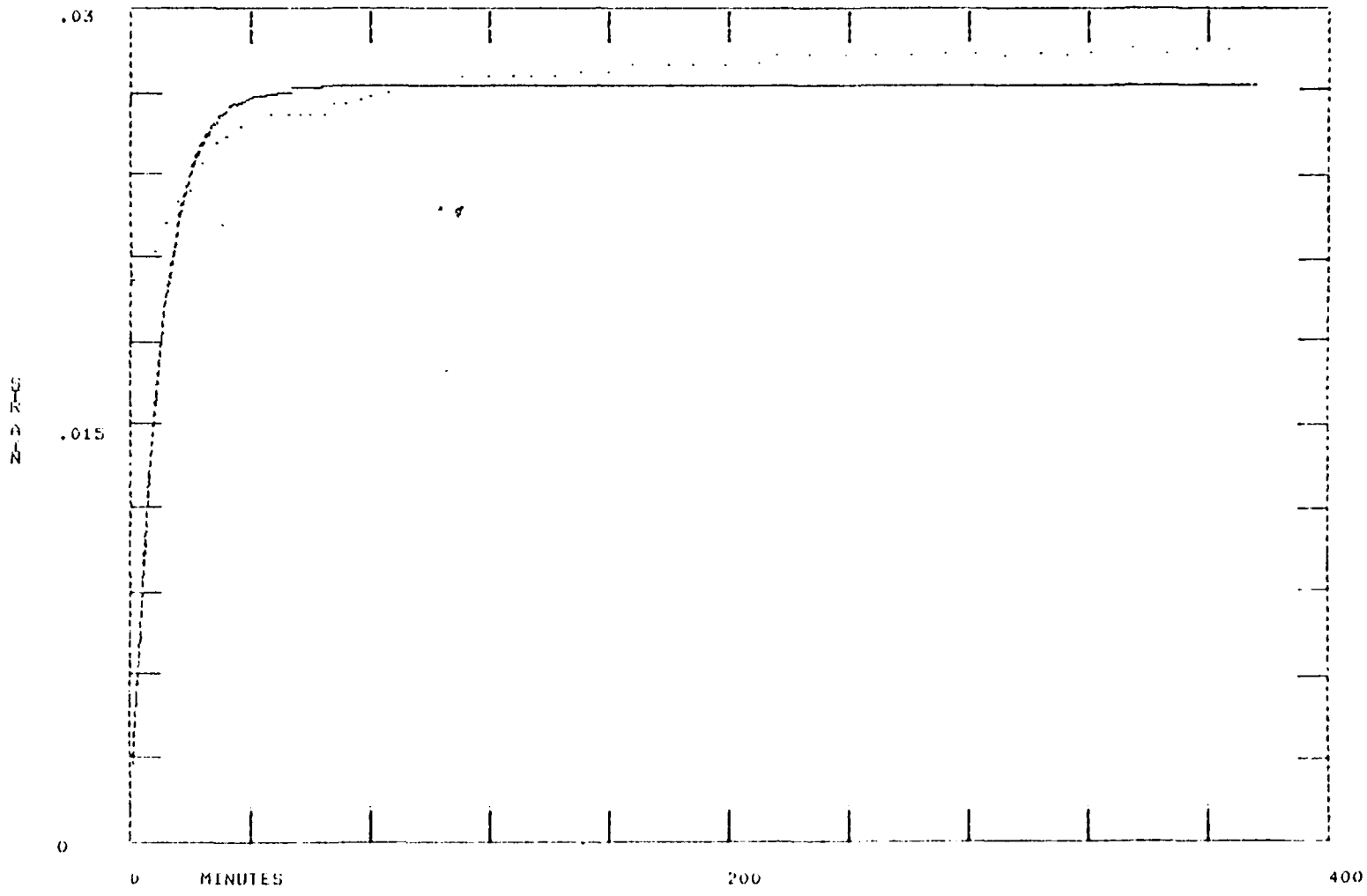
4-PARAMETER SOLID MODEL WITH VALUES OF
A1 = .0103516, B1 = .0224034, A2 = .0159235, B2 = .692289
DELTA TIME = 4
ERROR (USING ALL POINTS): 3.1357%
ERROR (IGNORING FIRST 3 POINTS): 2.2449%

IN 54 TO 17 19 FEB 75 AREA = 11.06 SQ CM HEIGHT = 2.6 CM
DOTTED LINE: ORIGINAL DATA HEAVY LINE: MODEL PREDICTION



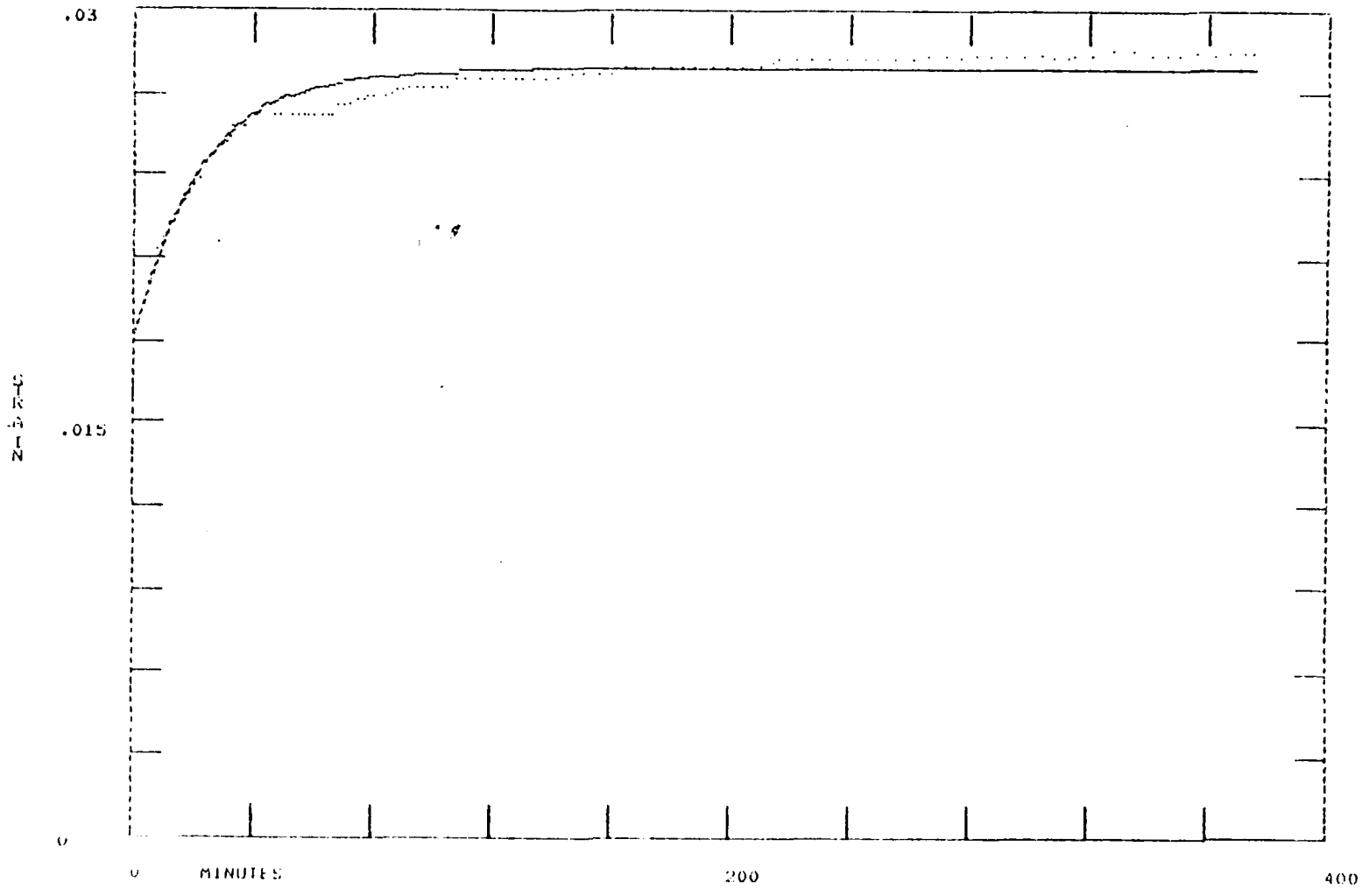
2 PARAMETER SOLID MODEL WITH VALUES OF
E1 = .01755535 E2 = .01726555
DELTA TIME = 16
ERROR (USING ALL POINTS) : 10.9260%
ERROR (IGNORING FIRST 5 POINTS) : 2.4465%

LE 64 12 10 Z 665 25 AREA = 13.69 50 CM HEIGHT = 2.66 CM
DOTTED LINE: EXPERIMENTAL DATA HEAVY LINE: MODEL PREDICTION



2-PARAMETER SOLID MODEL WITH VALUES OF
A1 = .022204 , B1 = .11038
DELTA TIME = 4
ERROR (USING ALL POINTS) : 3.5116%
ERROR (IGNORING FIRST 3 POINTS) : 1.5133%

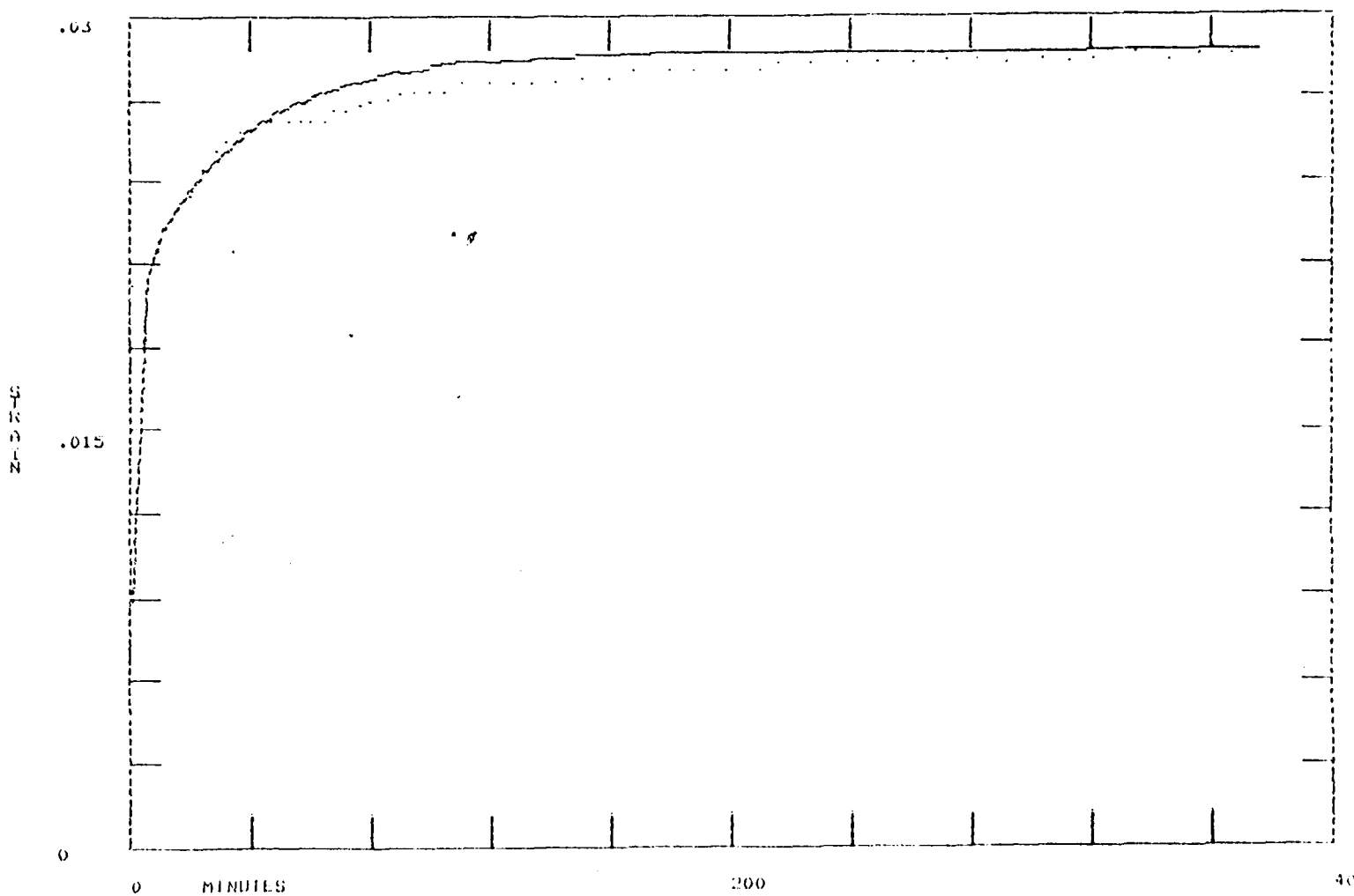
16:56 15 16 20 FEB 75 AREA = 14.73 SQ CM HEIGHT = 1.90 CM
DOTTED LINE: ORIGINAL DATA HEAVY LINE: MODEL PREDICTION



3 PARAMETER SOLID MODEL WITH VALUES OF
A1 = .022922 A2 = .044499 A3 = .012959
DELTA TIME = 4
ERROR: (COSTED DELTA POINTS): 0.648%
ERROR: (CORRECTED FIRST 3 POINTS): -0.053%

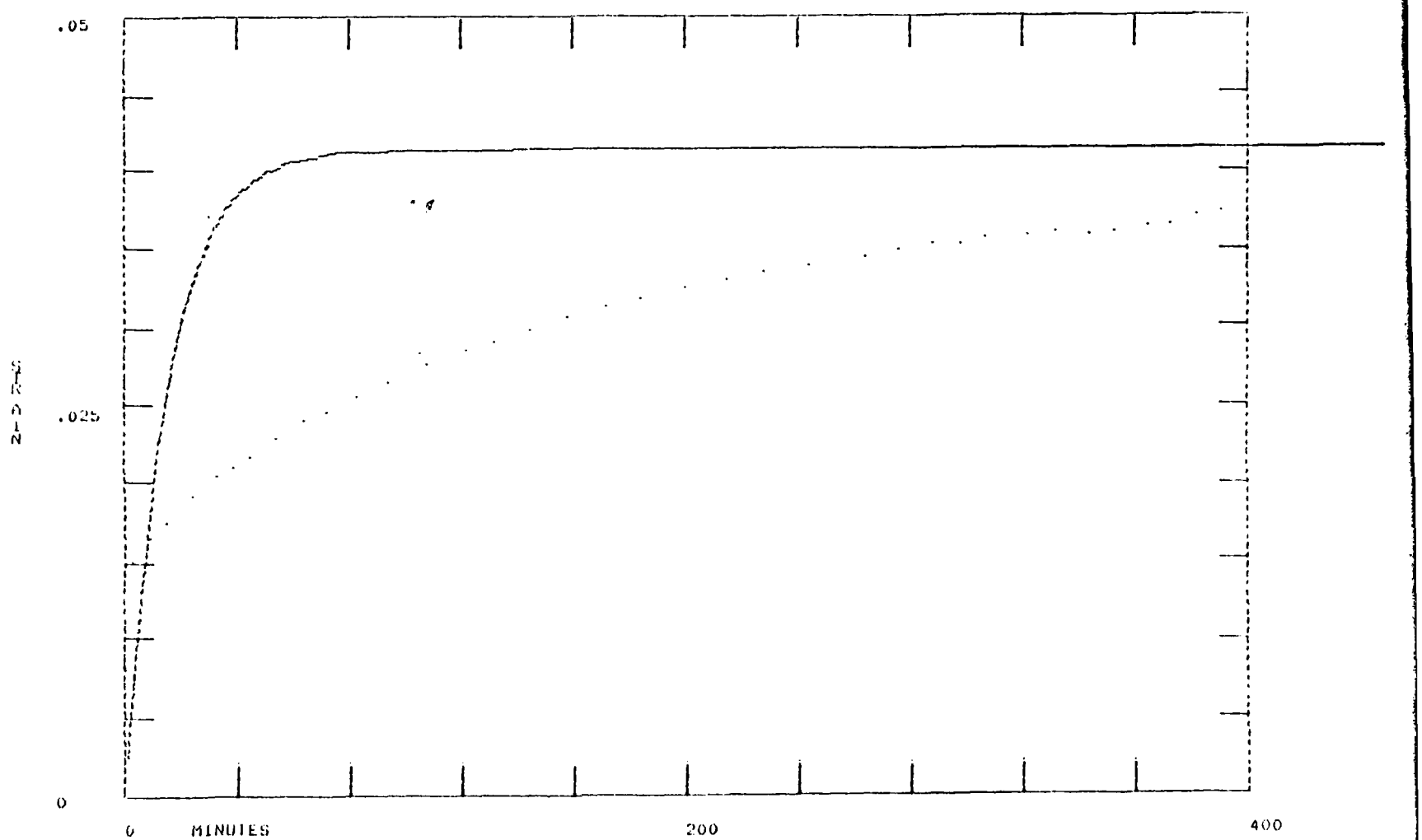
BLOCK 56 15 16 20 FEB 75 6AGA 14:23:50 GA HEIGHT = 1.90 CM
DOTTED LINE: OBSERVED DATA SOLID LINE: MODEL PREDICTION

111



4-PARAMETER SOLID MODEL WITH VALUES OF
A1 = 8.90389E-03, B1 = .0289354, A2 = .0197729, B2 = .5789
DELTA TIME = 4
ERROR (USING ALL POINTS): -0.332%
ERROR (IGNORING FIRST 3 POINTS): -1.576%

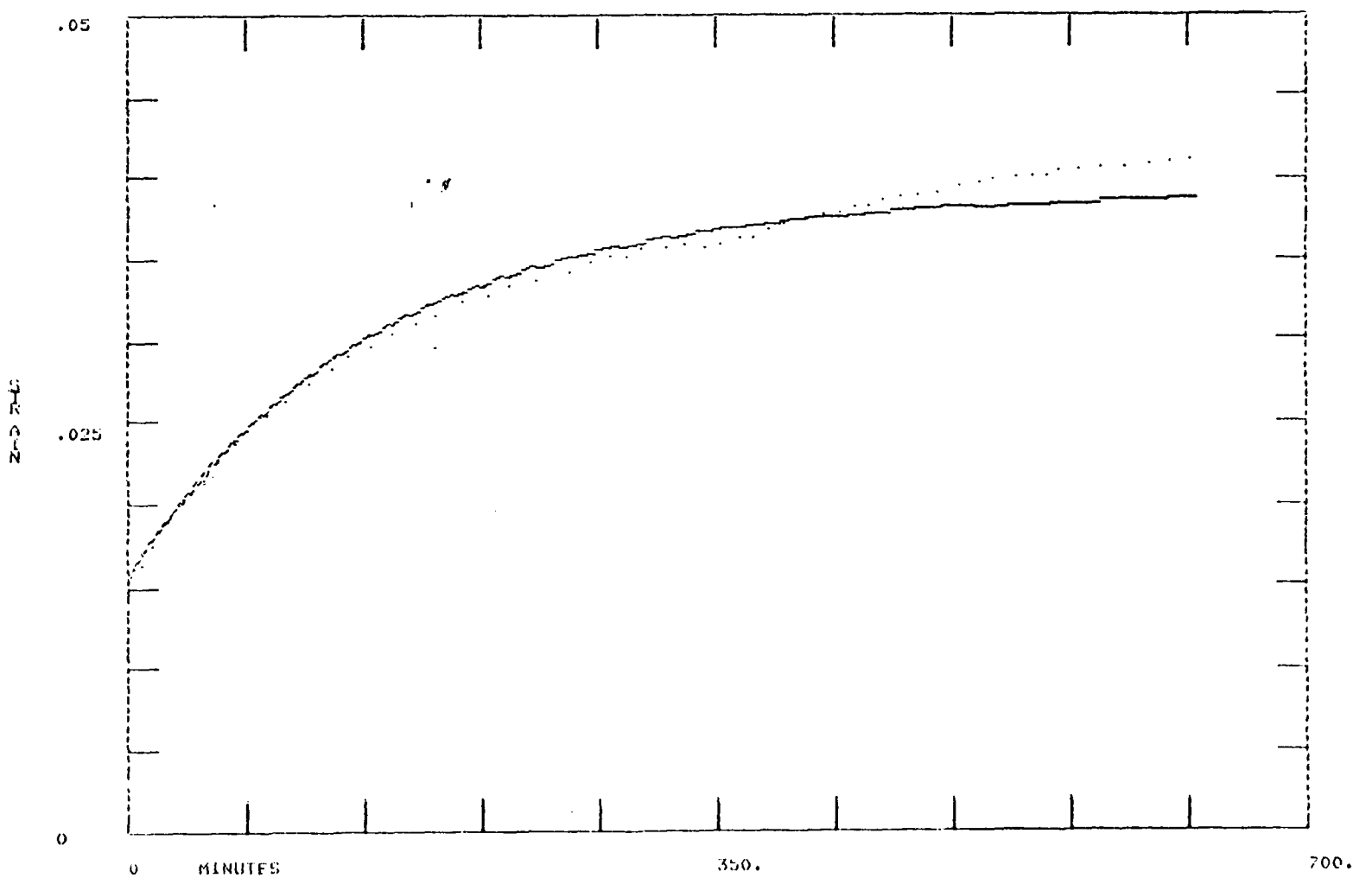
EX-56 15-16 20 FEB 75 AREA = 14.73 SQ CM HEIGHT = 1.98 CM
DOTTED LINE: ORIGINAL DATA HEAVY LINE: MODEL PREDICTION



2-PARAMETER SOLID MODEL WITH VALUES OF
A1 = .041505, B1 = .065202
DELTA TIME = 30
ERROR (USING ALL POINTS): -22.660%
ERROR (IGNORING FIRST 3 POINTS): -32.0332%

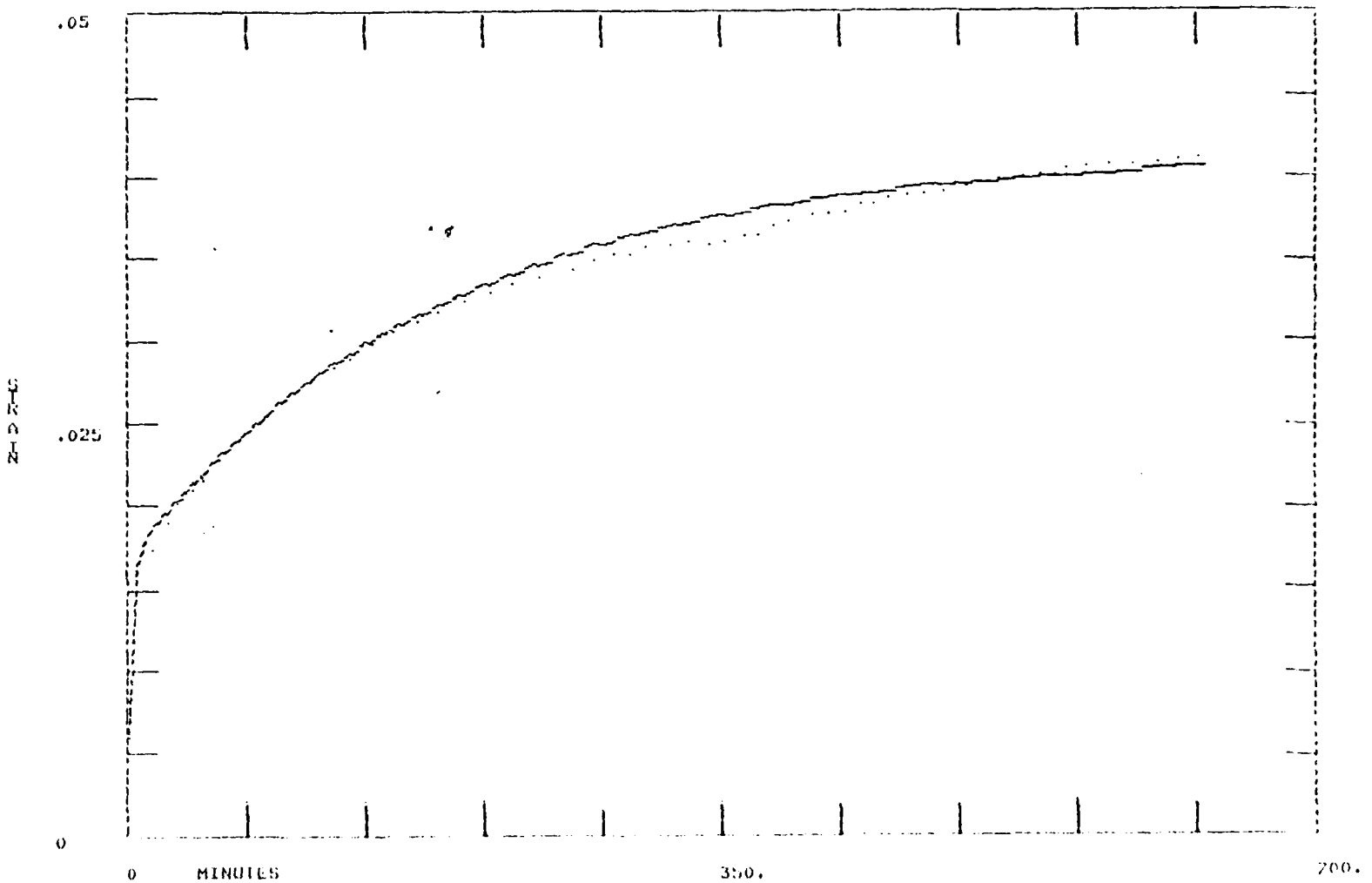
LK-57 T2-T3 13 FEB 75 AREA = 9.93 SQ CM HEIGHT = 2.16 CM
DOTTED LINE: ORIGINAL DATA HEAVY LINE: MODEL PREDICTION

3



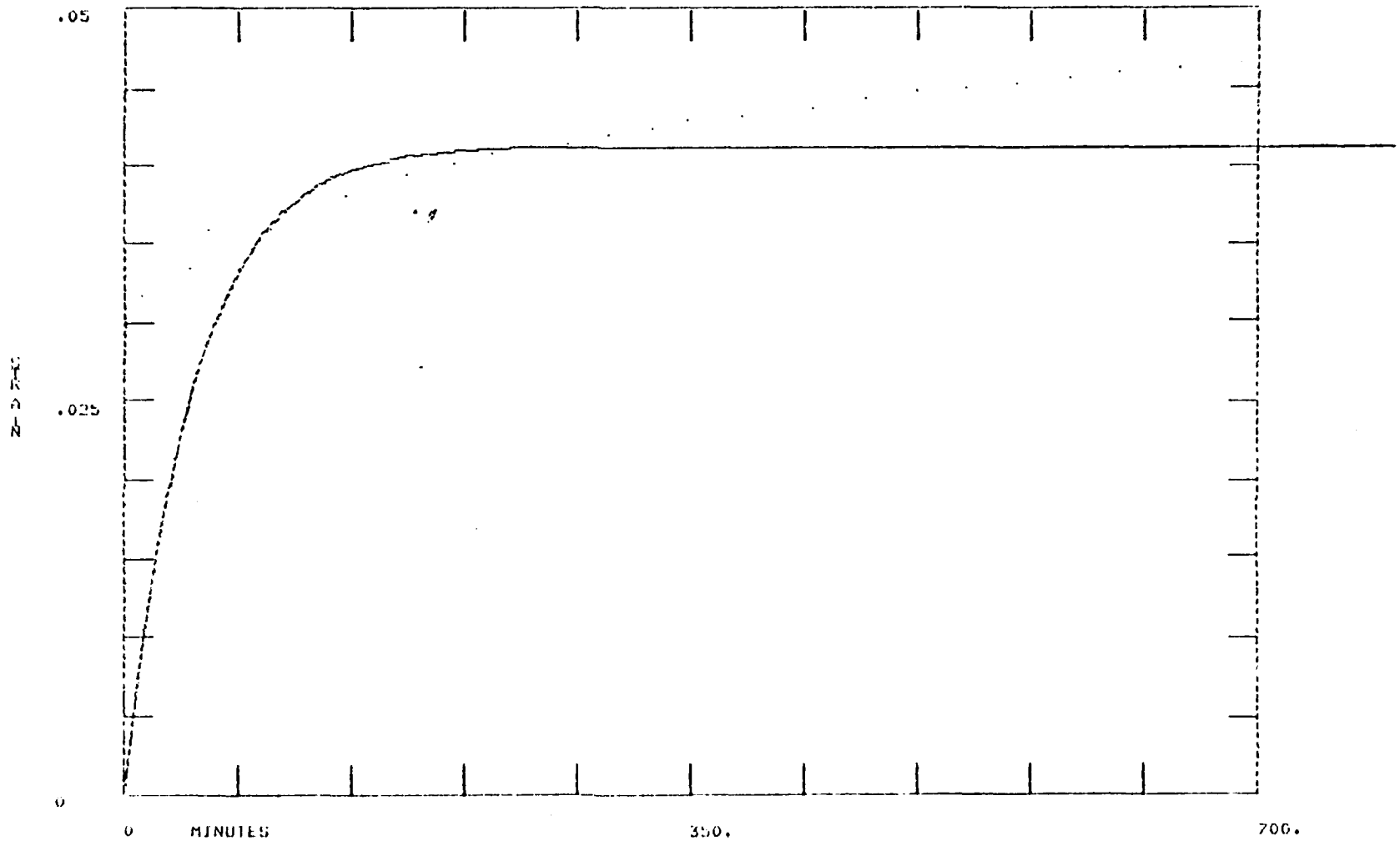
3-PARAMETER SOLID MODEL WITH VALUES OF
A1 = .039031, B1 = 6.8847E-03, A2 = .015748
DELTA TIME = 16
ERROR (USING ALL POINTS): 1.183%
ERROR (IGNORING FIRST 3 POINTS): 0.690%

EK-57 12-13 13 FEB 75 AREA = 9.93 50 CM HEIGHT = 2.16 CM
DOTTED LINE: ORIGINAL DATA HEAVY LINE: MODEL PREDICTION



4-PARAMETER SOLID MODEL WITH VALUES OF
A1 = .016824, B1 = .458857, A2 = .0245551, B2 = 5.37115E-03
DELTA TIME = 8
ERROR (USING ALL POINTS): -0.654%
ERROR (IGNORING FIRST 3 POINTS): -1.13%

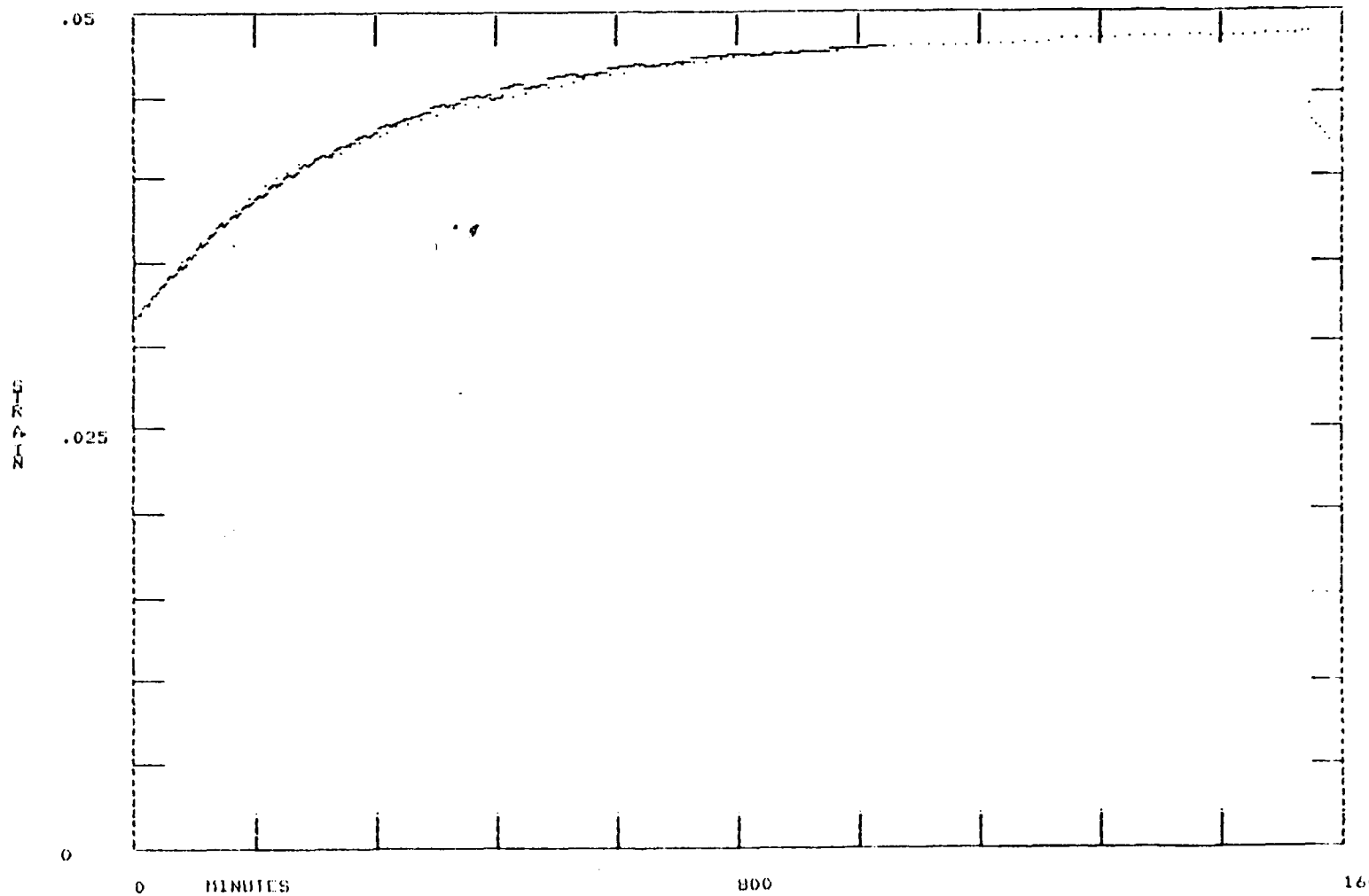
LK-57 12-13 13 FEB 75 AREA = 9.93 SQ CM HEIGHT = 2.16 CM
DOTTED LINE: ORIGINAL DATA HEAVY LINE: MODEL PREDICTION



2-PARAMETER SOLID MODEL WITH VALUES OF
AL = .0413722, BL = .0232213
DELTA TIME = 16
ERROR (USING ALL POINTS): 9.3572%
ERROR (IGNORING FIRST 3 POINTS): 4.8622%

LN-59 19-110 24 FEB 75 AREA = 16.01 SQ CM HEIGHT = 2.775 CM
DOTTED LINE: ORIGINAL DATA HEAVY LINE: MODEL PREDICTION

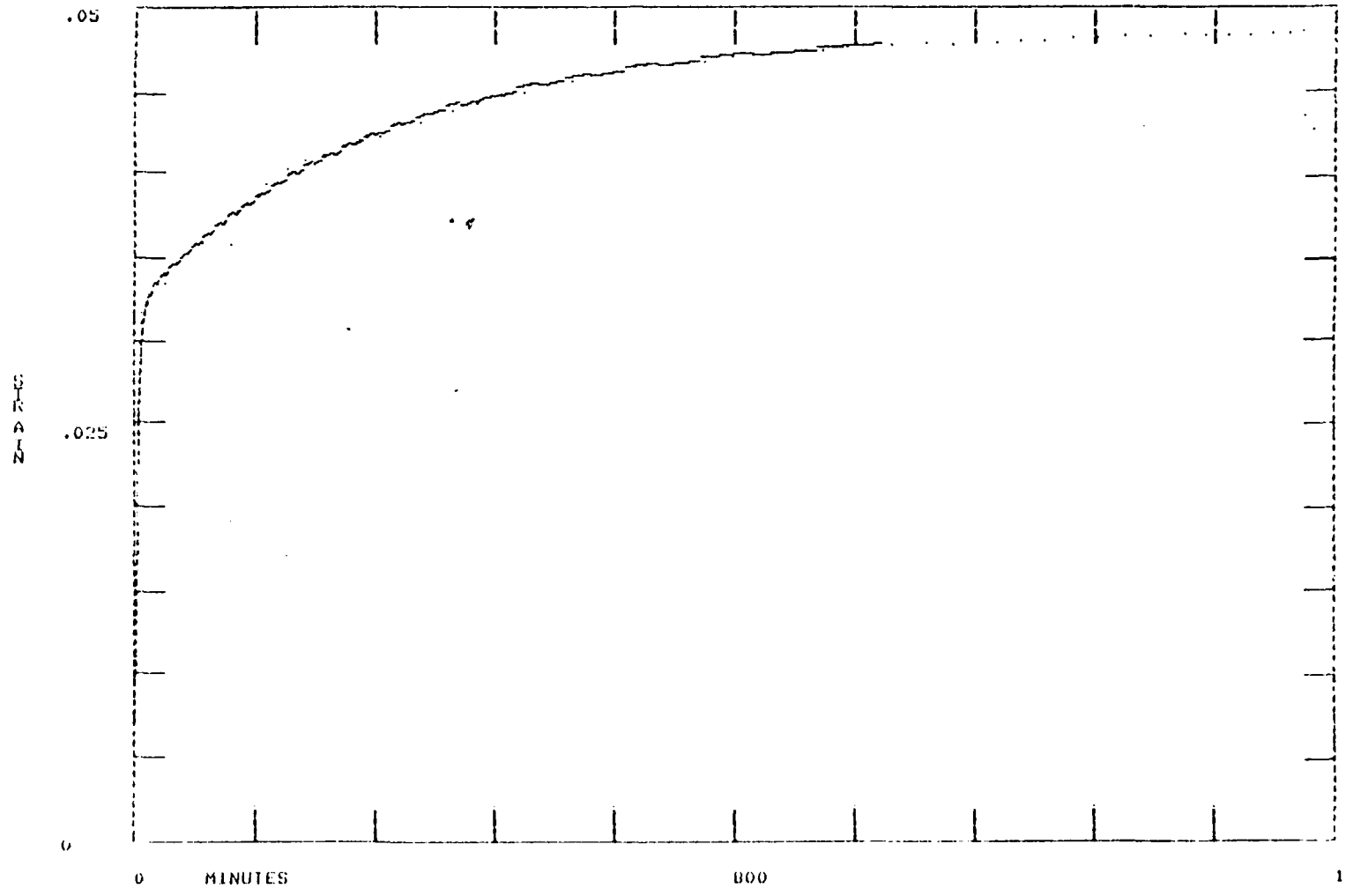
11c



3-PARAMETER SOLID MODEL WITH VALUES OF
A1 = .048225 , B1 = 3.5193E-05 , A2 = .031332
DELTA TIME = 4
ERROR (USING ALL POINTS) : -0.238%
ERROR (IGNORING FIRST 3 POINTS) : 0.044%

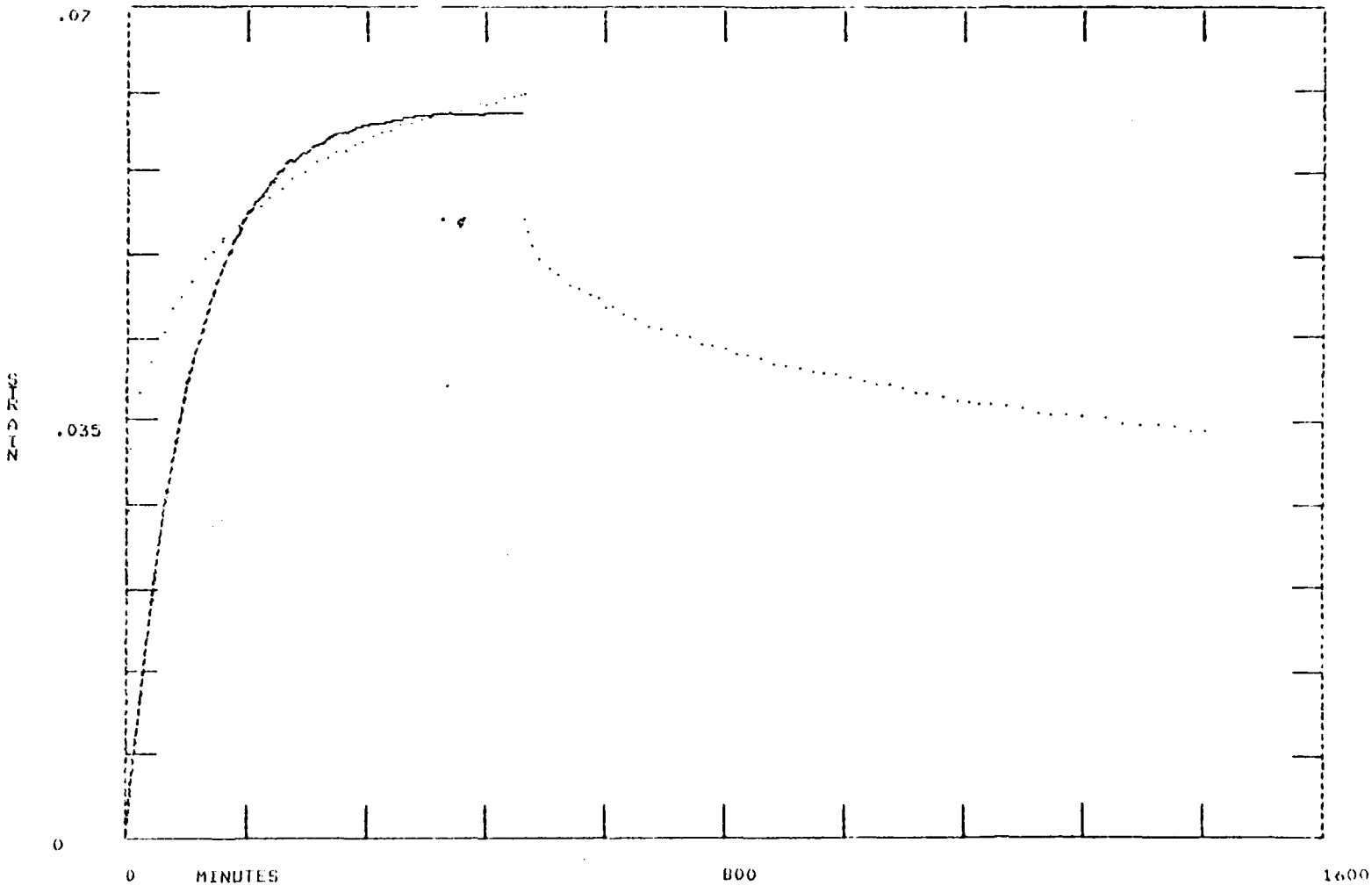
LN 59 19:10 24 FEB 75 AREA = 16.01 SQ IN HEIGHT = 2.775 CM
DOTTED LINE: ORIGINAL DATA HEAVY LINE: MODEL PREDICTION

17



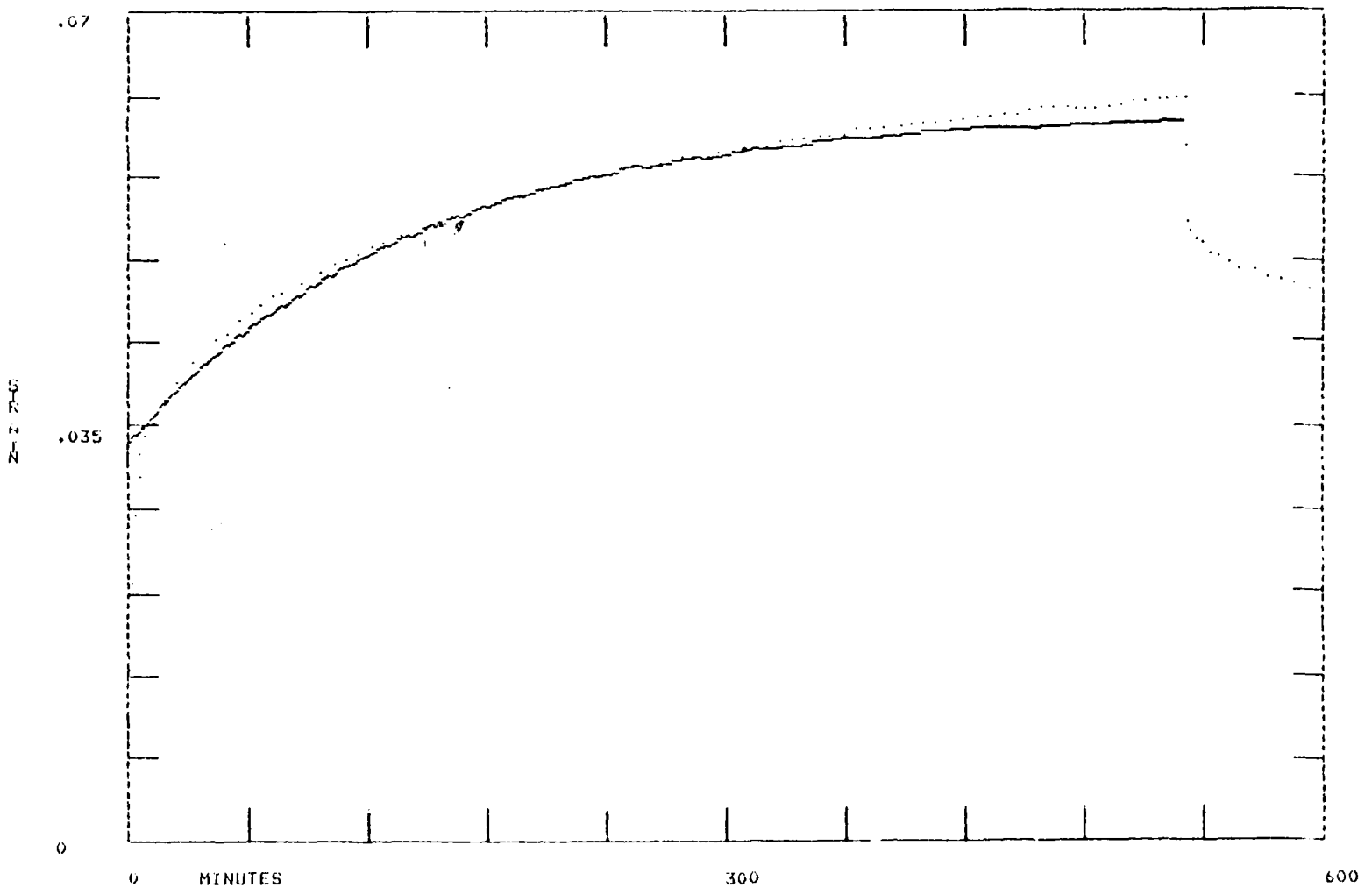
4-PARAMETER SOLID MODEL WITH VALUES OF
A1 = .0321261, B1 = .259092, A2 = .0163332, B2 = 3.02592E-03
DELTA TIME = 4
ERRORS (USING ALL POINTS): 0.592%
ERRORS (IGNORING FIRST 3 POINTS): 0.039%

LA 59 19 110 24 FEB 75 AREA = 16.01 SQ CM HEIGHT = 2.775 CM
DOTTED LINE: ORIGINAL DATA HEAVY LINE: MODEL PREDICTION



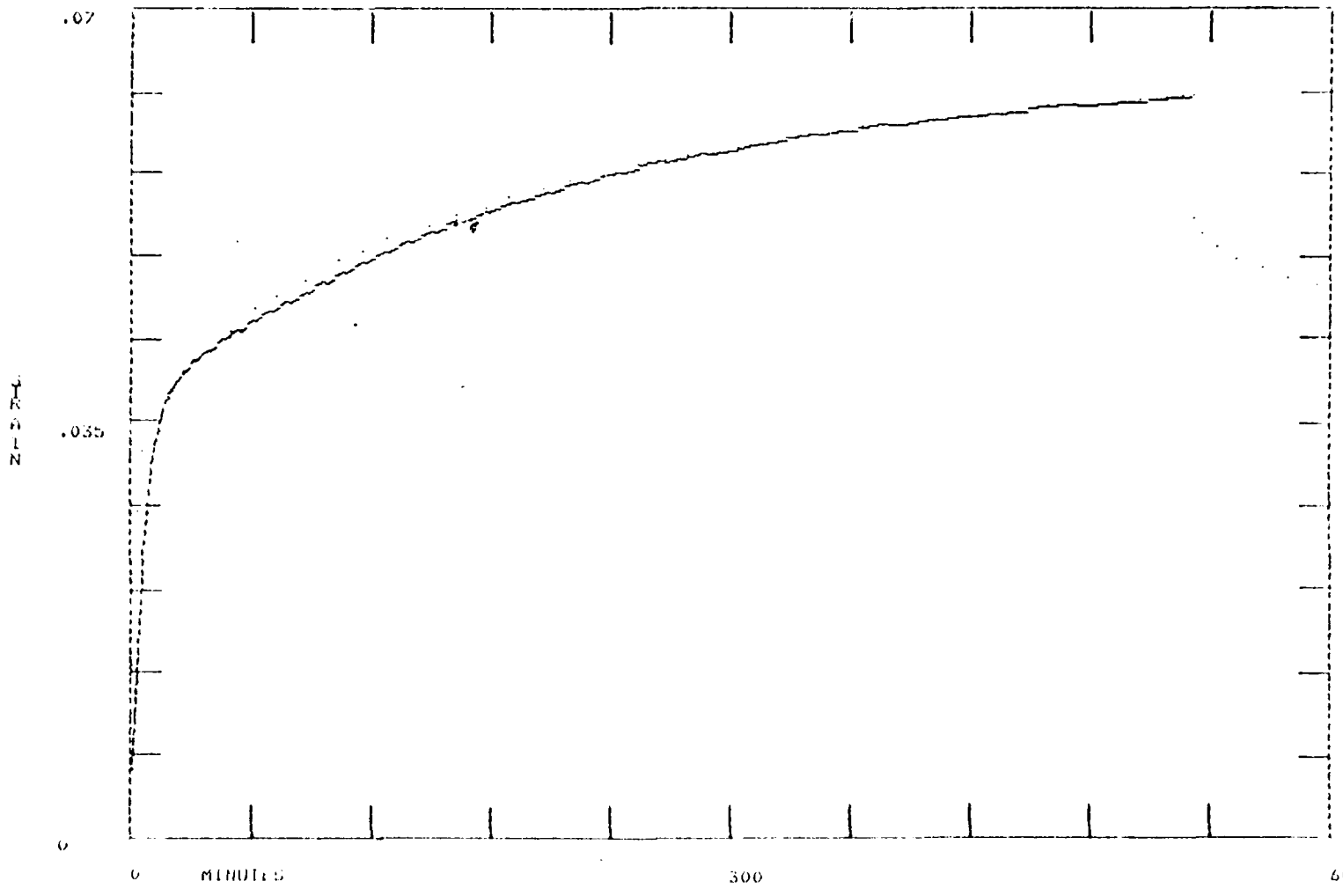
2-PARAMETER SOLID MODEL WITH VALUES OF
A1 = .061524, B1 = .01193
DELTA TIME = 16
ERROR (USING ALL POINTS): 2.902%
ERROR (IGNORING FIRST 3 POINTS): 5.166%

LK-60 14-15 26 FEB 75 AREA = 11.14 SQ CM HEIGHT = 2.24 CM
DOTTED LINE: ORIGINAL DATA HEAVY LINE: MODEL PREDICTION



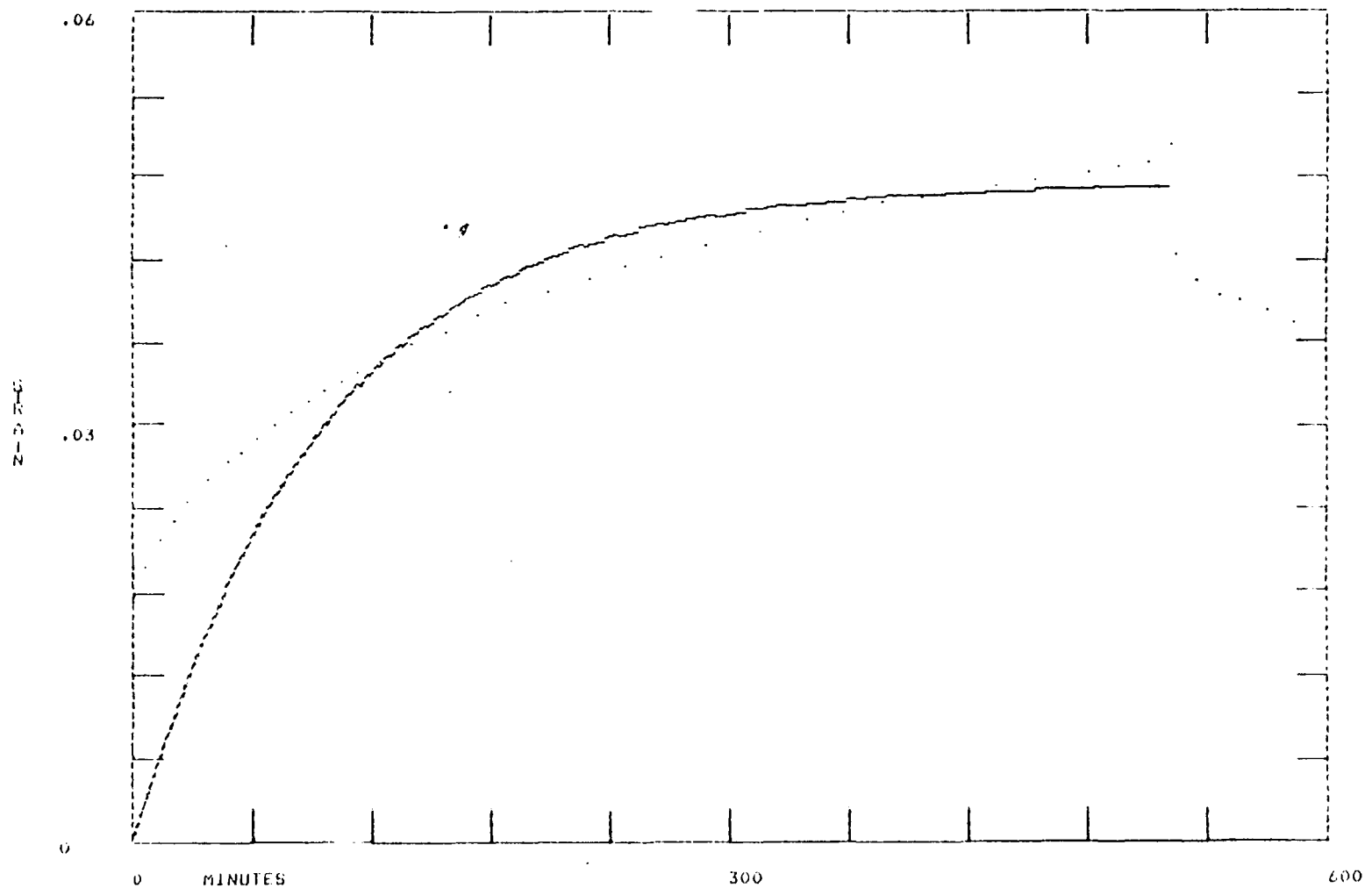
3-PARAMETER SOLID MODEL WITH VALUES OF
A1 = .061668, B1 = 6.9353E-03, A2 = .0335548
DELTA TIME = 4
ERROR (USING ALL POINTS): 0.306%
ERROR (IGNORING FIRST 3 POINTS): 0.922%

LN-60 14-15 28 FEB 75 AREA = 11.14 SQ CM HEIGHT = 2.24 CM
DOTTED LINE: ORIGINAL DATA HEAVY LINE: MODEL PREDICTION



4-PARAMETER SOLID MODEL WITH VALUES OF
D1 = .036098, E1 = .17404, D2 = .0288821, E2 = 4.84445E-03
DELTA TIME = 4
ERROR (USING ALL POINTS): 1.855%
ERROR (IGNORING FIRST 3 POINTS): 0.705%

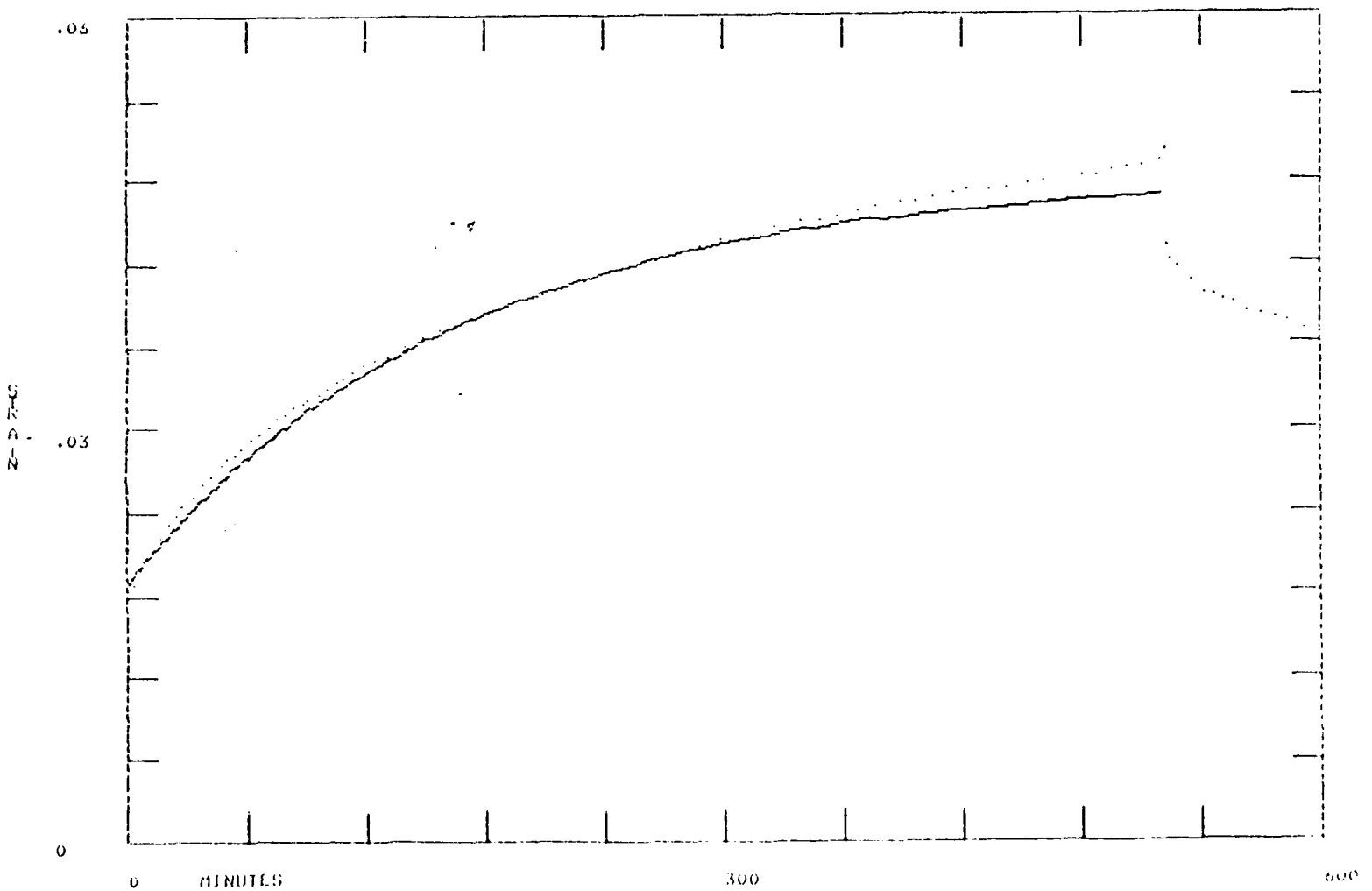
TK-50 14:15 20 FEB 75 AREA = 11.14 SQ CM HEIGHT = 2.24 CM
DOTTED LINE: ORIGINAL DATA HEAVY LINE: MODEL PREDICTION



2-PARAMETER SOLID MODEL WITH VALUES OF
A1 = .042461, B1 = .010447
DELTA TIME = 16

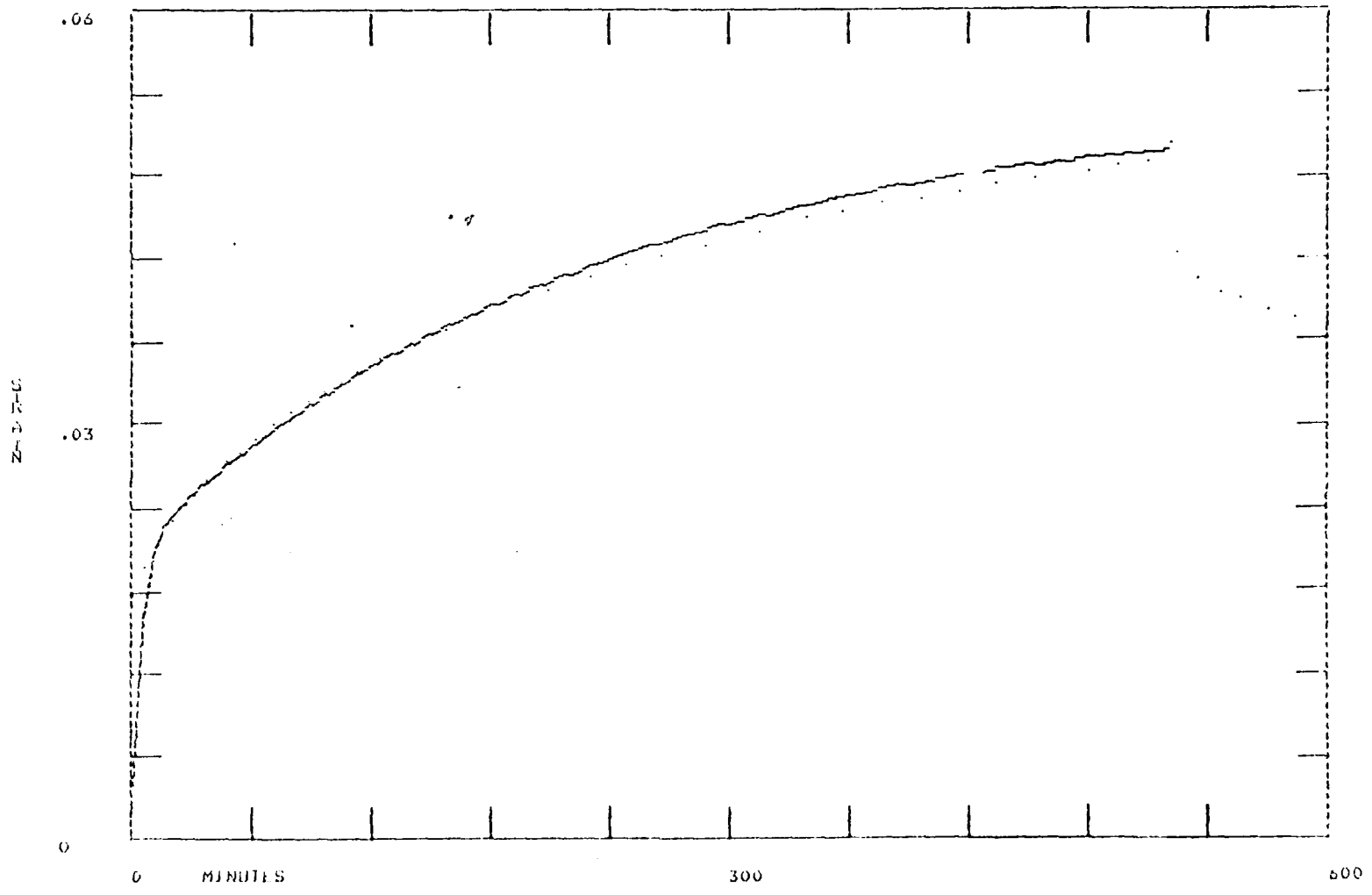
ERROR (USING ALL POINTS): 9.431%
ERROR (IGNORING FIRST 3 POINTS): 6.264%

LN-61 15-16 3 MAR 75 AREA = 10.43 50 CM HEIGHT = 1.895 CM
DOTTED LINE: ORIGINAL DATA HEAVY LINE: MODEL PREDICTION



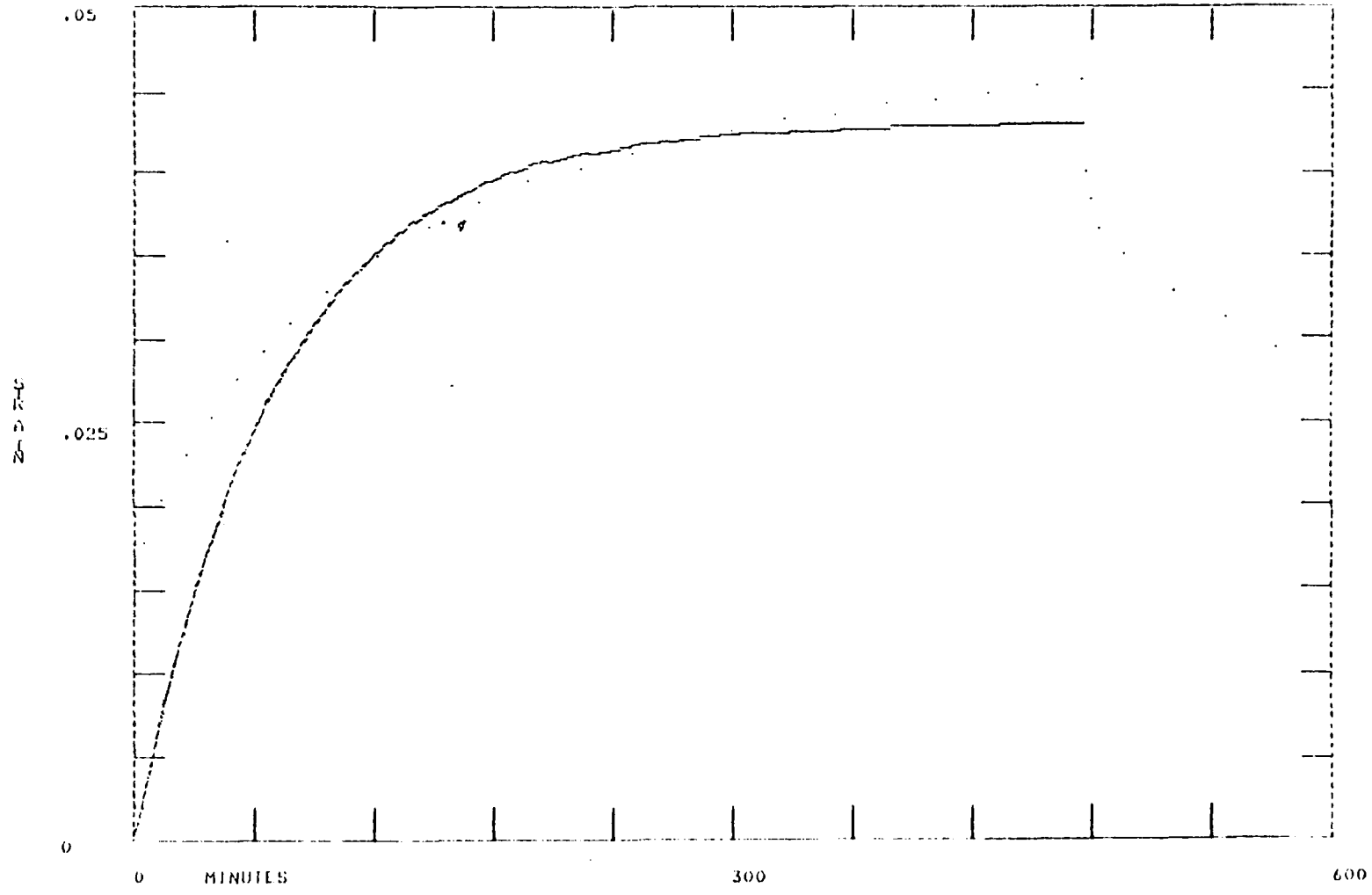
3-PARAMETER SOLID MODEL WITH VALUES OF
A1 = .048246, B1 = 6.0272E-03, A2 = .01902
DELTA TIME = 30
ERROR (USING ALL POINTS): 2.0668%
ERROR (IGNORING FIRST 3 POINTS): 2.0365%

LN-61 15-16 3 MAR 75 AREA = 10.43 SQ CM HEIGHT = 1.895 CM
DOTTED LINE: ORIGINAL DATA HEAVY LINE: MODEL PREDICTION



4-PARAMETER SOLID MODEL WITH VALUES OF
A1 = .0221092, B1 = .215923, A2 = .0322252, B2 = 4.33488E-03
DELTA TIME = 4
ERROR (USING ALL POINTS): 1.486%
ERROR (IGNORING FIRST 3 POINTS): -0.651%

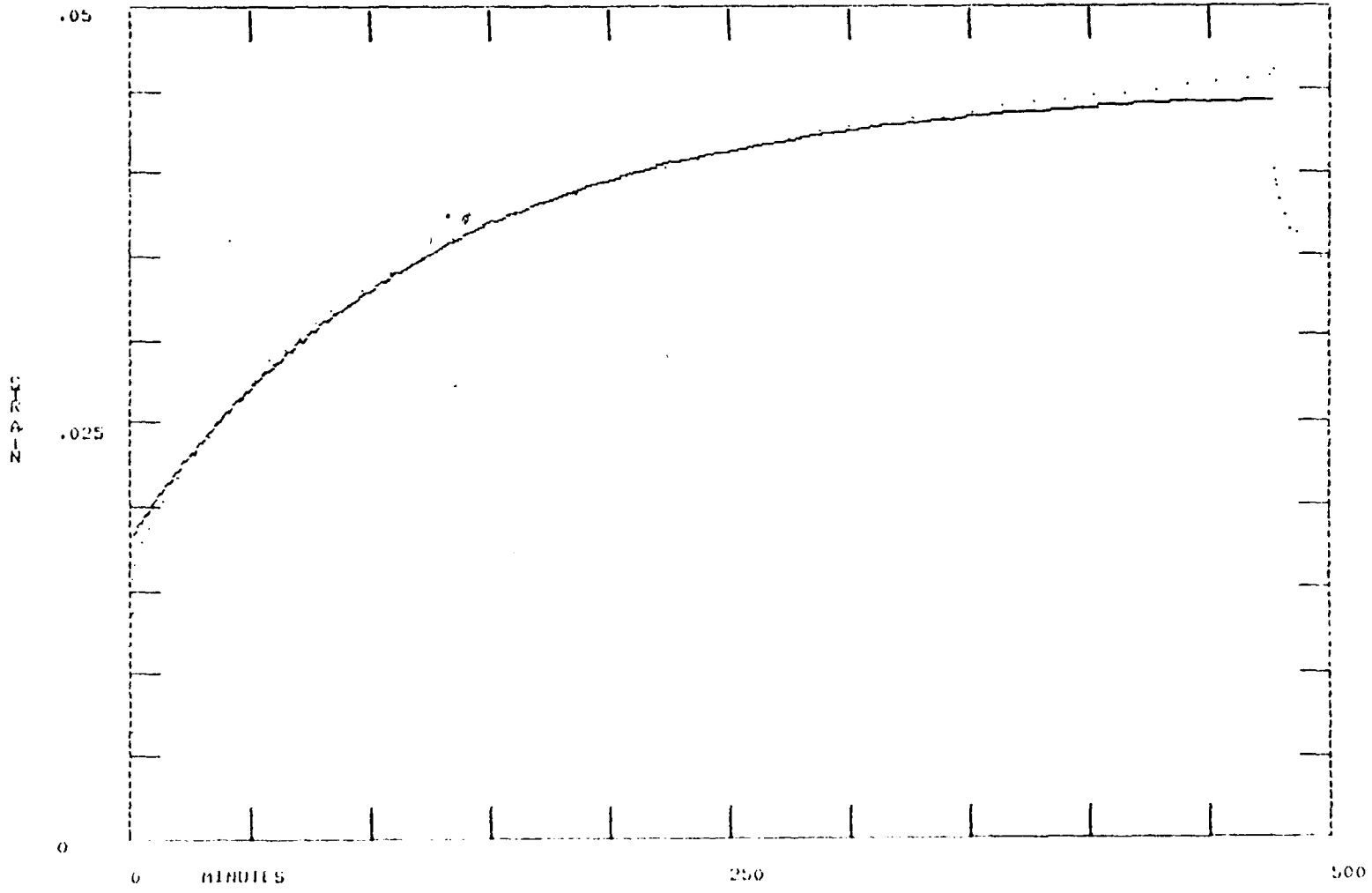
EX 61 TS 16 3 MAR 75 AREA = 10.43 SQ CM HEIGHT = 1.895 CM
DOTTED LINE: ORIGINAL DATA HEAVY LINE: MODEL PREDICTION



2 PARAMETER TIME SOLID MODEL WITH VALUES OF
BETA = .04299[illegible] XI = .014163
BETA IN TIME = 8
ERROR (USING ALL POINTS) : 10.2992%
ERROR (IGNORING FIRST 3 POINTS) : 6.3488%

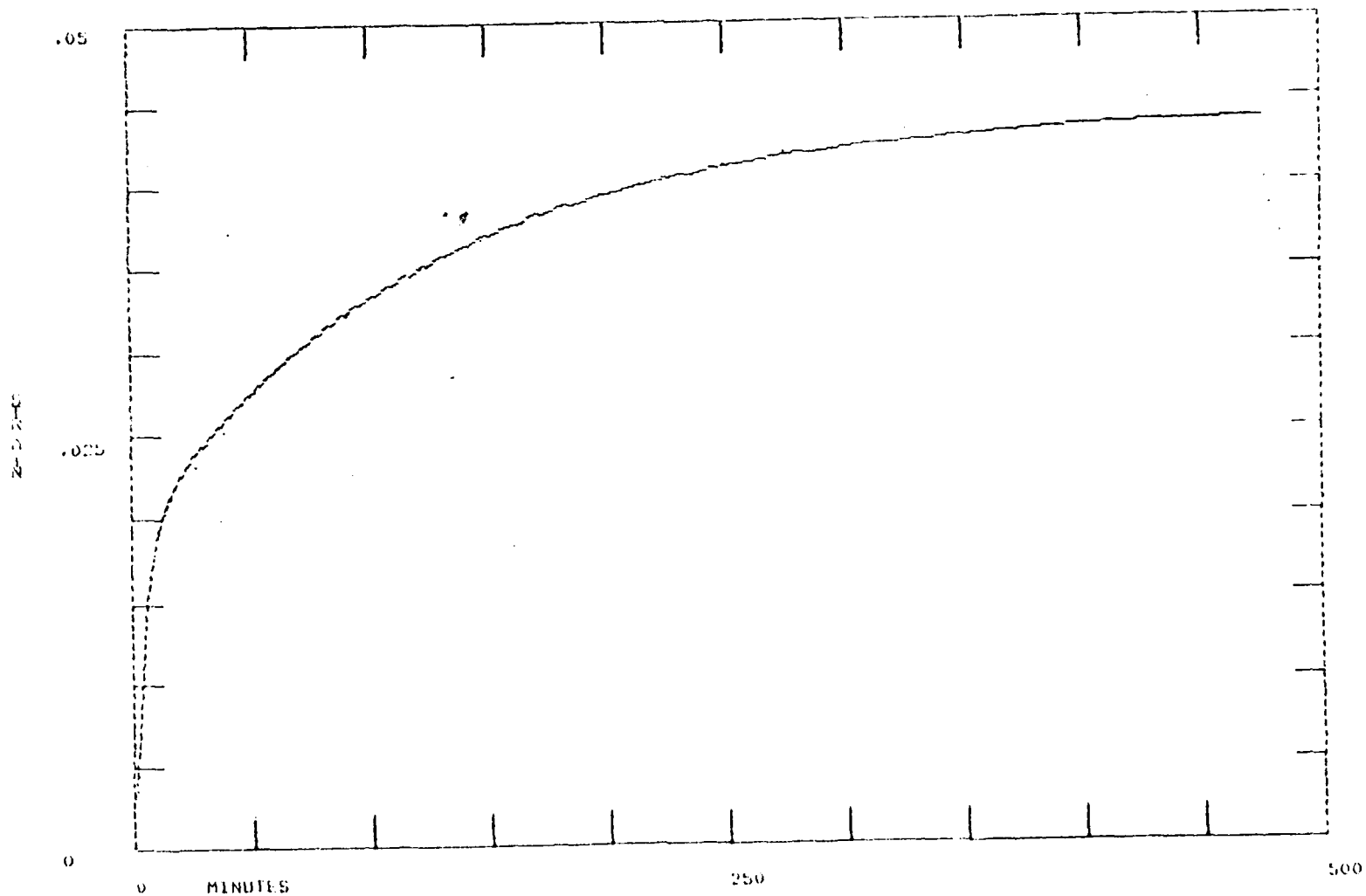
LN-62 16 17 5 MAR 75 AREA = 12.33 SQ CM HEIGHT = 1.85 CM
DOTTED LINE: ORIGINAL DATA HEAVY LINE: MODEL PREDICTION

125



3-PARAMETER SOLID MODEL WITH VALUES OF
A1 = .045055, E1 = 7.99136E-05, A2 = .0182245
DELTA TIME = 8
ERROR (USING ALL POINTS): -0.3597%
ERROR (IGNORING FIRST 3 POINTS): 0.5697%

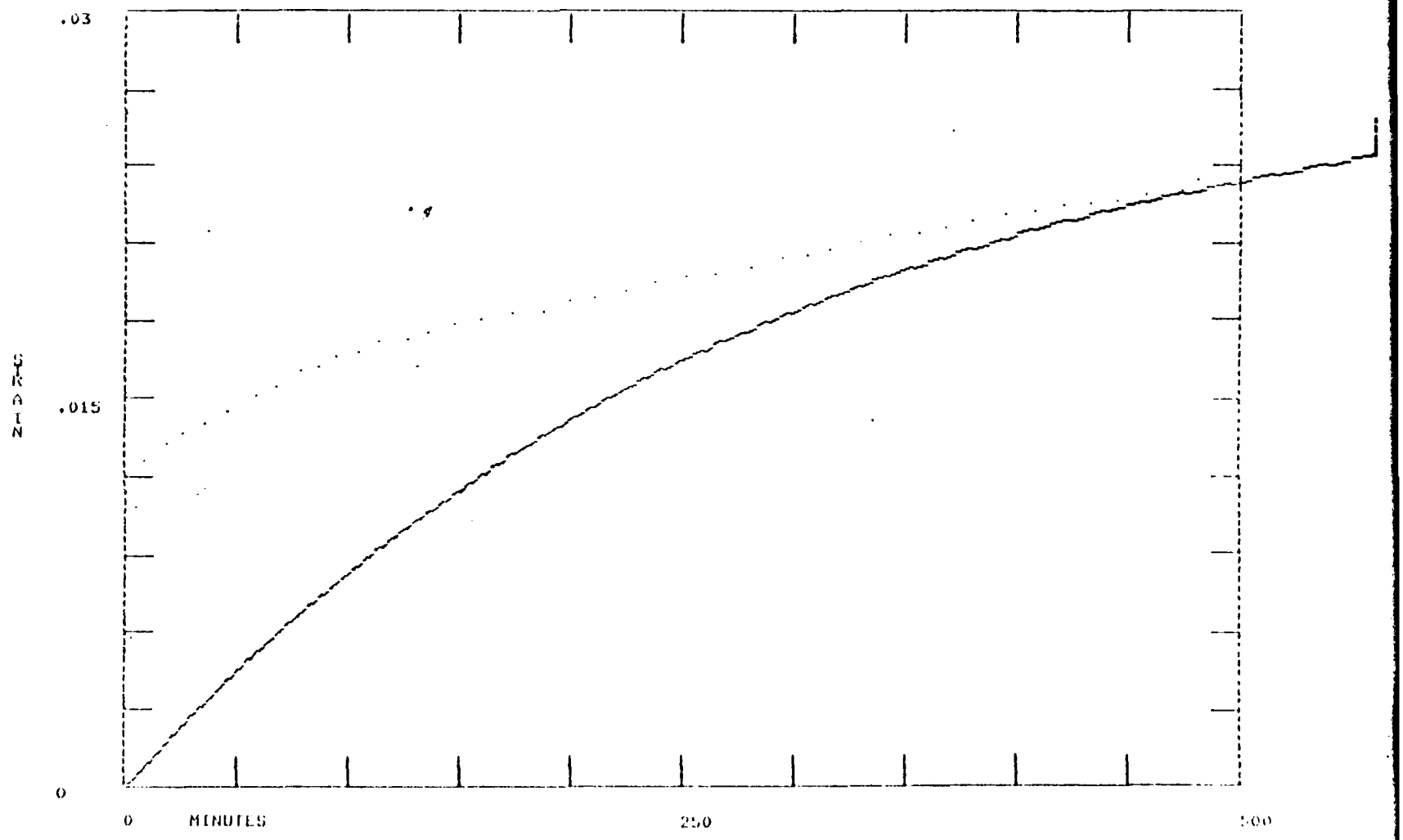
LN 62 16:17 5 MAR 75 AREA = 12.34 SQ CM HEIGHT = 1.05 CM
DOTTED LINE: ORIGINAL DATA HEAVY LINE: MODEL PREDICTION



4-PARAMETER SOLID MODEL WITH VALUES OF
A1 = .0255346, B1 = 8.28832E-05, A2 = .019021, B2 = .22008
DELTA TIME = 8
ERROR (USING ALL POINTS): 5.227922
ERROR (IGNORING FIRST 3 POINTS): 1.111212

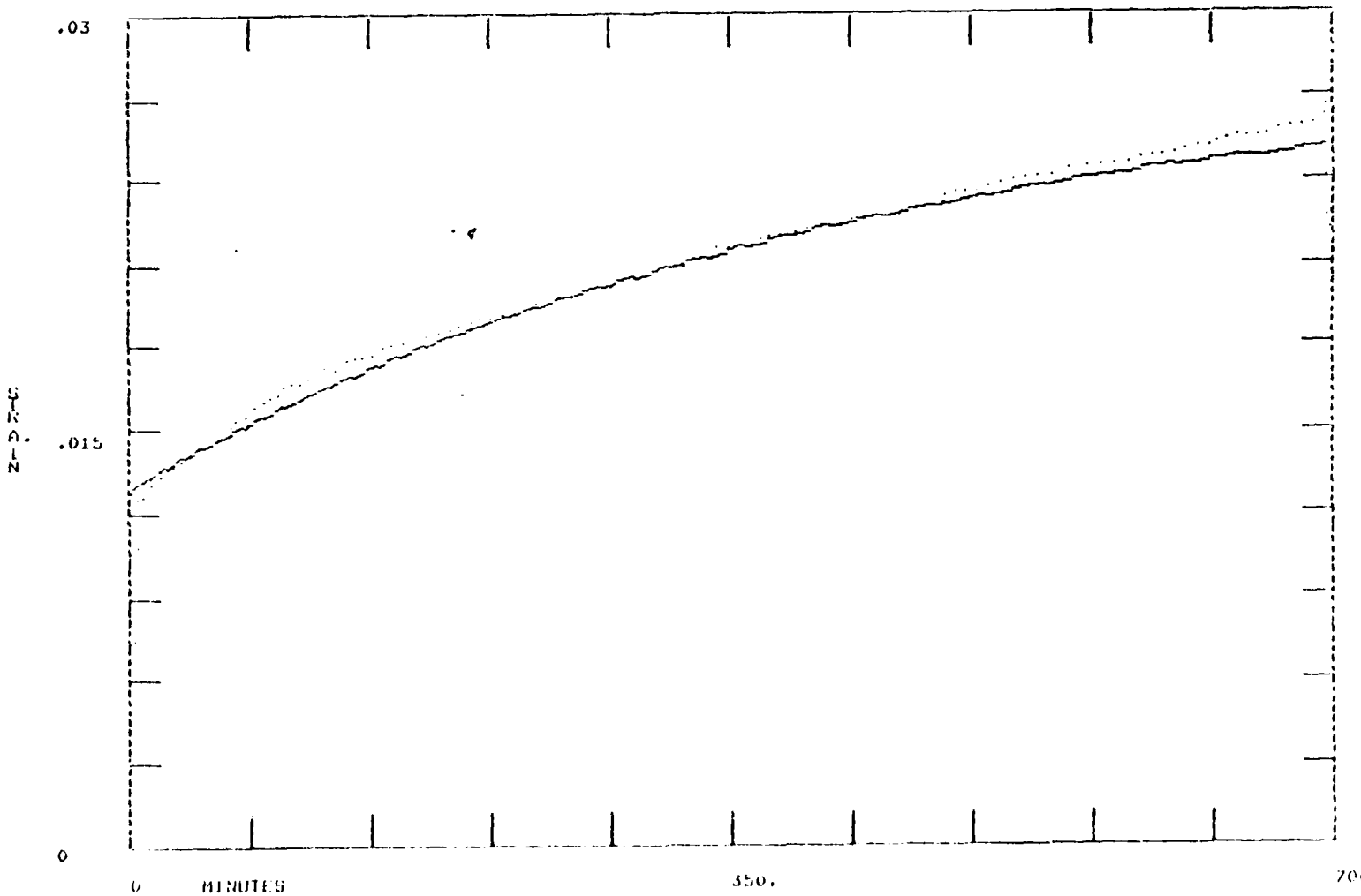
LK 62 16 17 5 MAR 75 AREA = 12.56 SQ CM HEIGHT 1.05 CM
BOTTOM LINE: ORIGINAL DATA HEAVY LINE: MODEL PREDICTION

107



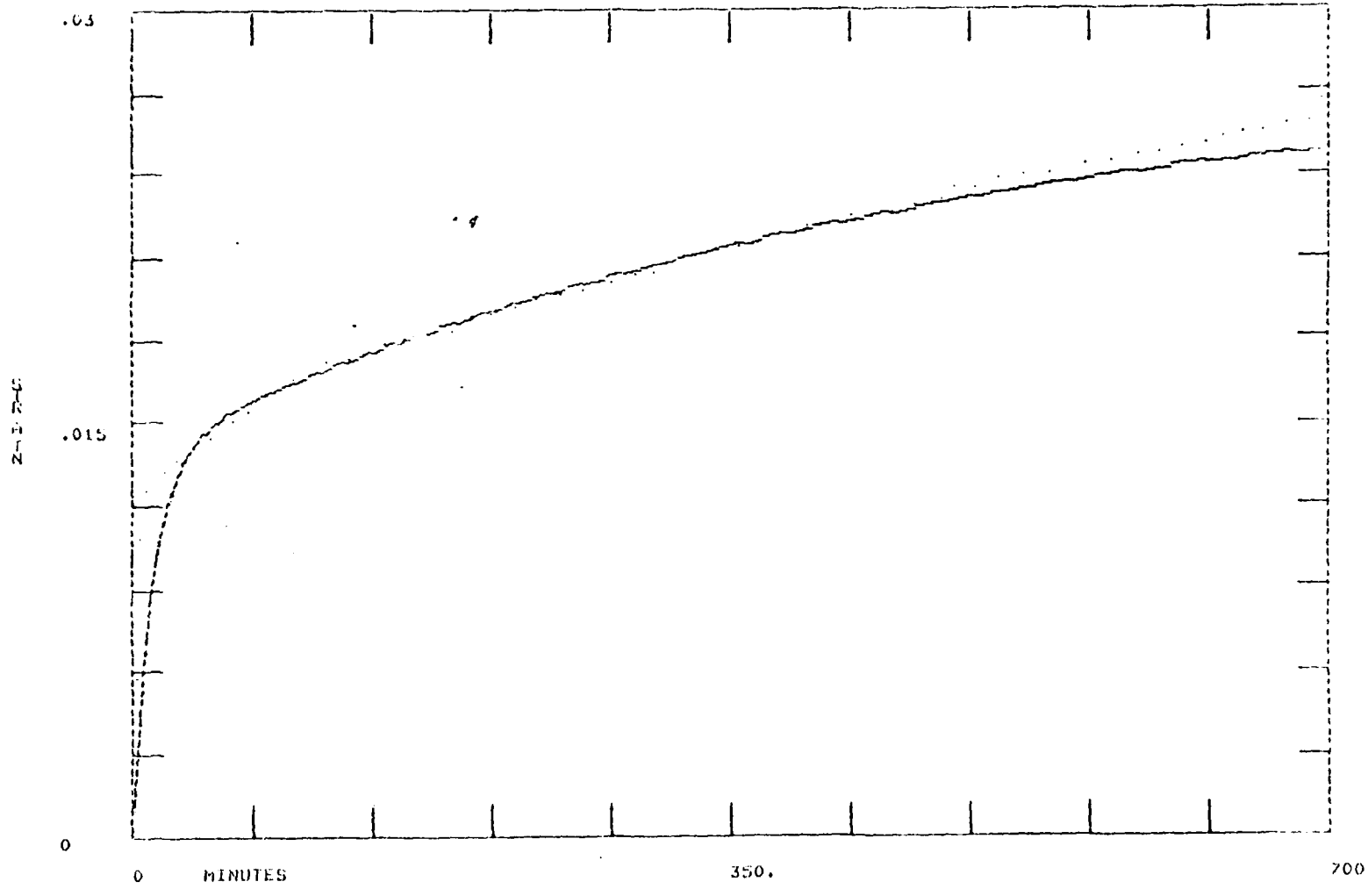
2-PARAMETER SOLID MODEL WITH VALUES OF
AL = .0203549, BL = 3.44056E-05
DELTA TIME = 4
ERROR (USING ALL POINTS): 219.492%
ERROR (IGNORING FIRST 3 POINTS): 222.9659%

LK-63 T11-T12 6 MAR 75 AREA = 16.5 80 CM HEIGHT = 2.975 CM
DOTTED LINE: ORIGINAL DATA HEAVY LINE: MODEL PREDICTION



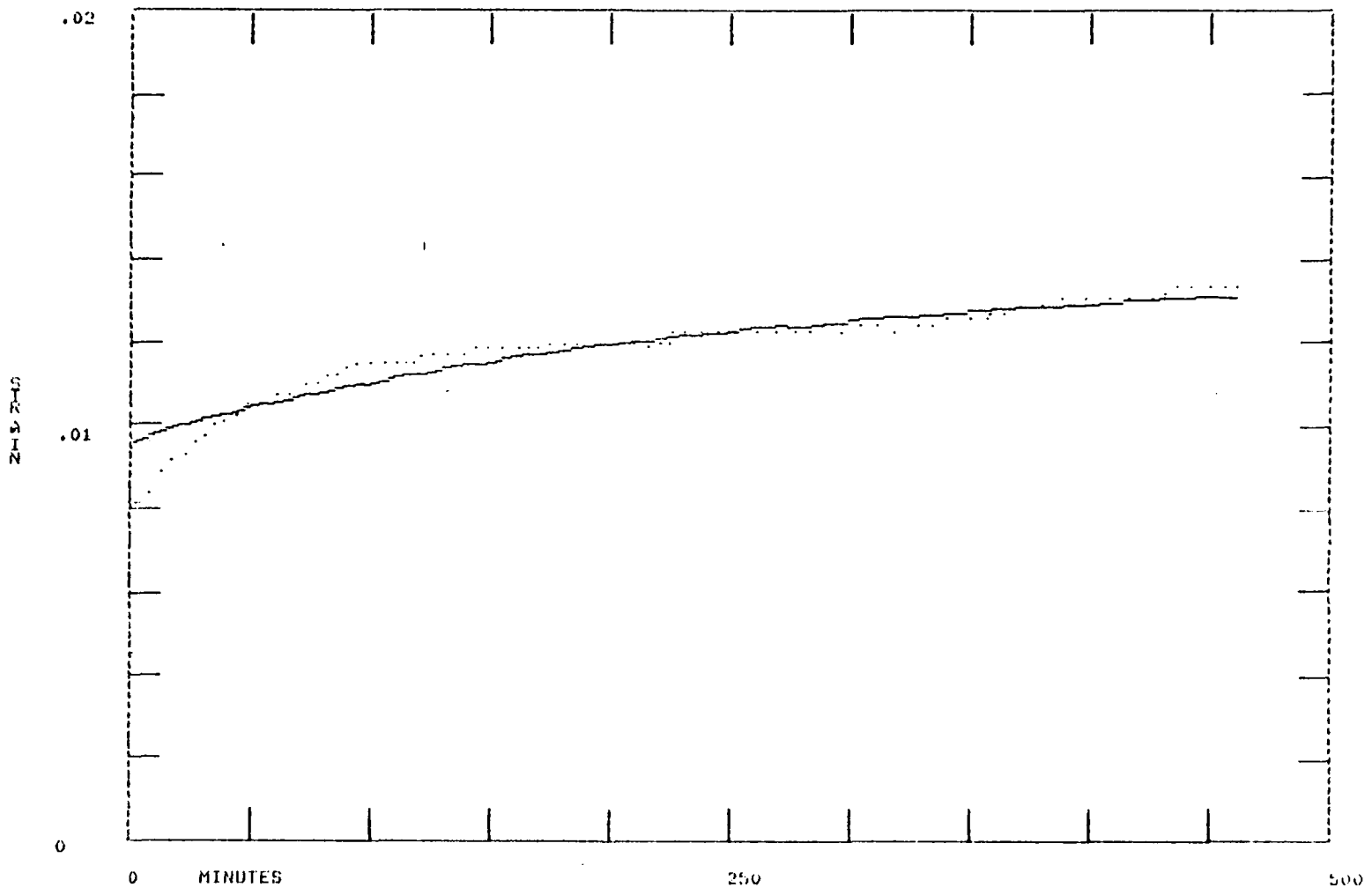
3-PARAMETER SOLID MODEL WITH VALUES OF
A1 = .022802, E1 = 2.36359E-03, A2 = .012853
DELTA TIME = 4
ERROR (USING ALL POINTS): 0.963%
ERROR (IGNORING FIRST 3 POINTS): 1.459%

LK-63 III-T12 6 MAR 75 AREA = 16.550 CM HEIGHT = 2.975 CM
DOTTED LINE: ORIGINAL DATA HEAVY LINE: MODEL PREDICTION



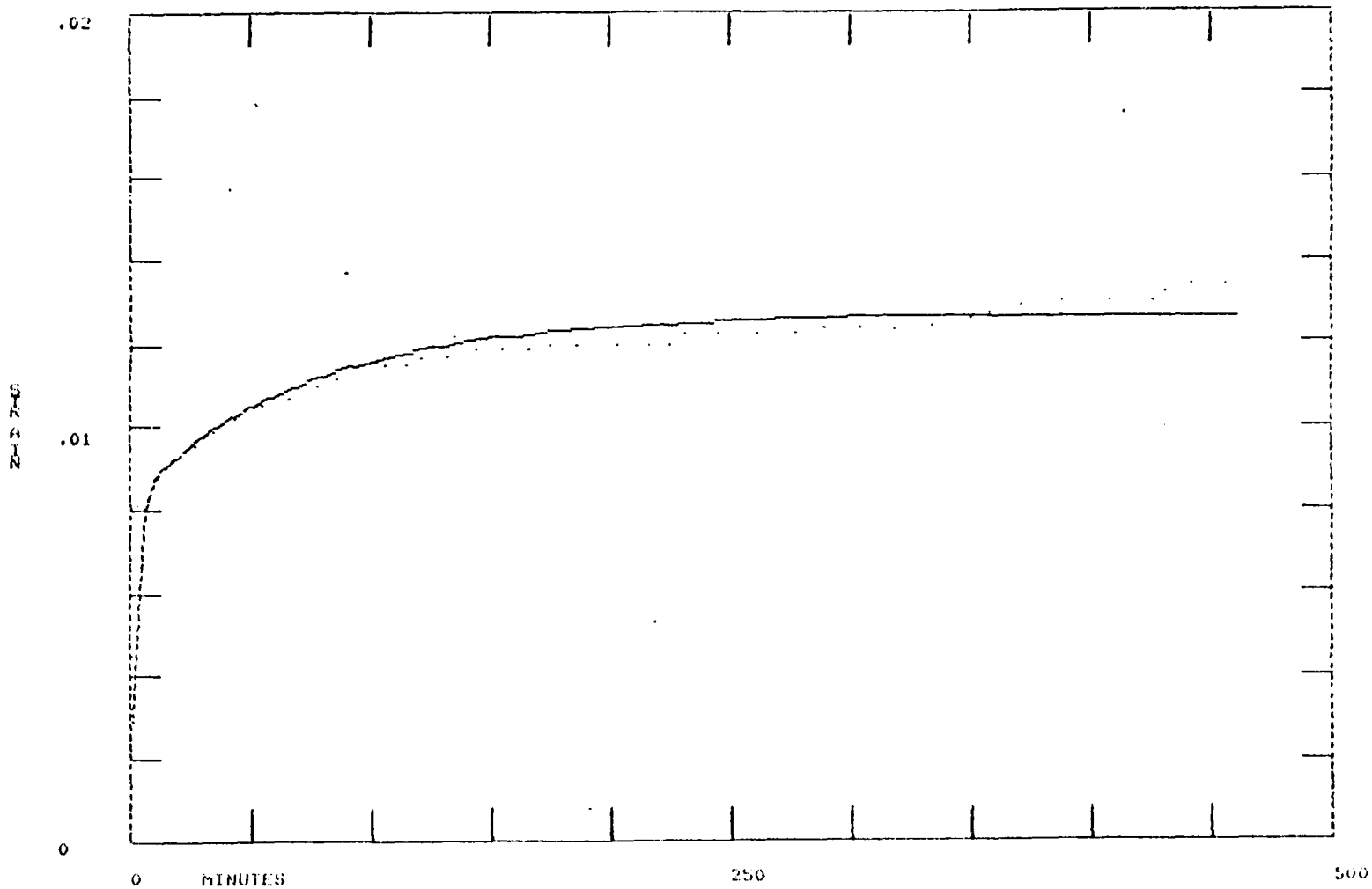
4-PARAMETER SOLID MODEL WITH VALUES OF
A1 = .013835, B1 = .0853, A2 = .01402, B2 = 2.2295E-03
DELTA TIME = 4
ERROR (USING ALL POINTS): 2.413%
ERROR (IGNORING FIRST 3 POINTS): 1.229%

IK-65 T11-T12 6 MAR 75 AREA = 16.5 50 CM HEIGHT = 2.925 CM
DOTTED LINE: ORIGINAL DATA HEAVY LINE: MODEL PREDICTION



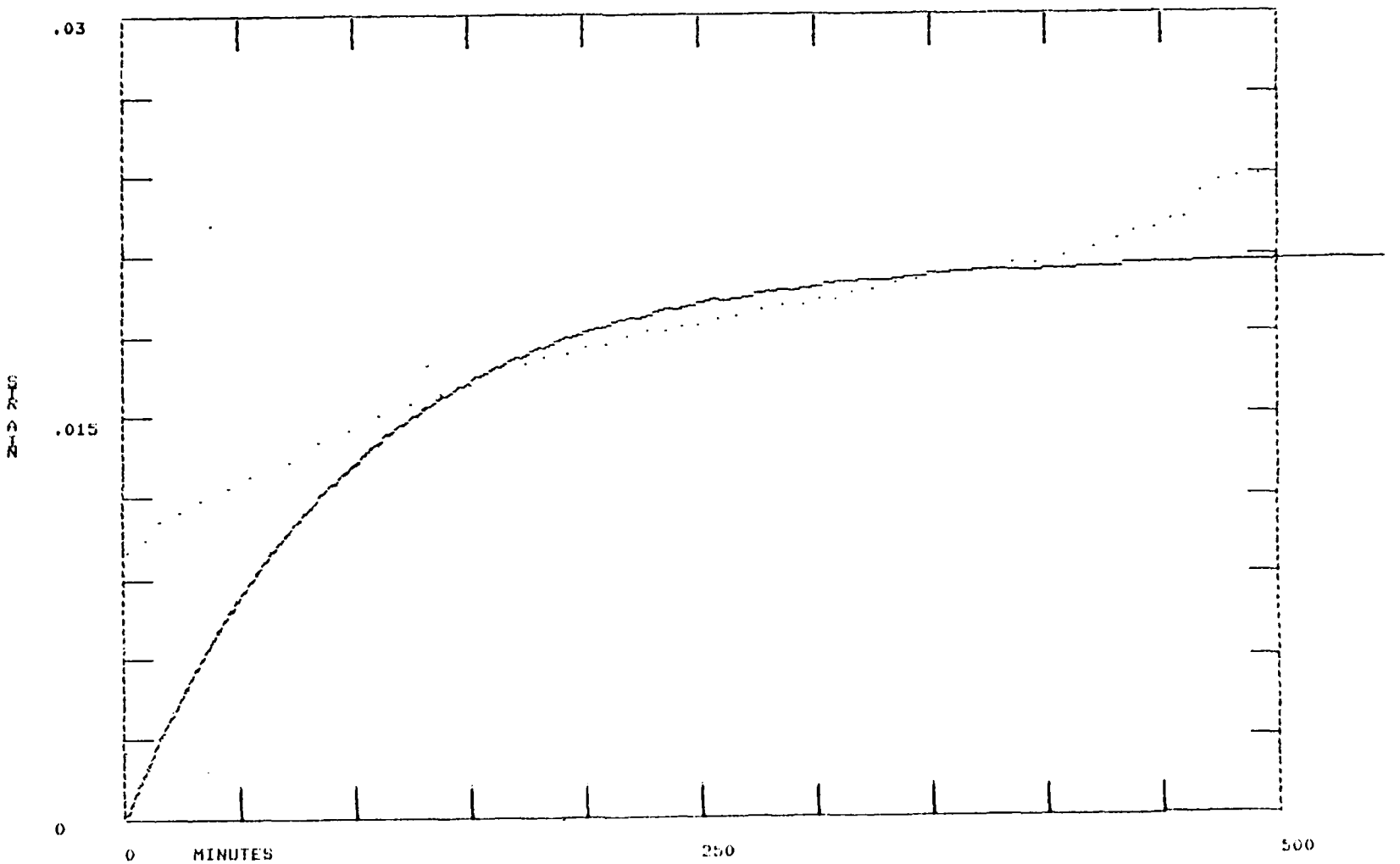
3-PARAMETER SOLID MODEL WITH VALUES OF
A1 = .013837, B1 = 3.9809E-03, A2 = .009679
DELTA TIME = 4
ERROR (USING ALL POINTS): -0.729%
ERROR (IGNORING FIRST 3 POINTS): -0.057%

LK-64 IZ-18 7 MAR 75 AREA = 13.69 SQ CM HEIGHT = 2.66 CM
DOTTED LINE: ORIGINAL DATA HEAVY LINE: MODEL PREDICTION



4-PARAMETER SOLID MODEL WITH VALUES OF
A1 = 8.33592E-03, K1 = .432388, A2 = 4.32661E-03, K2 = .0132718
DELTA TIME = 8
ERROR (USING ALL POINTS): 0.143%
ERROR (IGNORING FIRST 3 POINTS): -0.615%

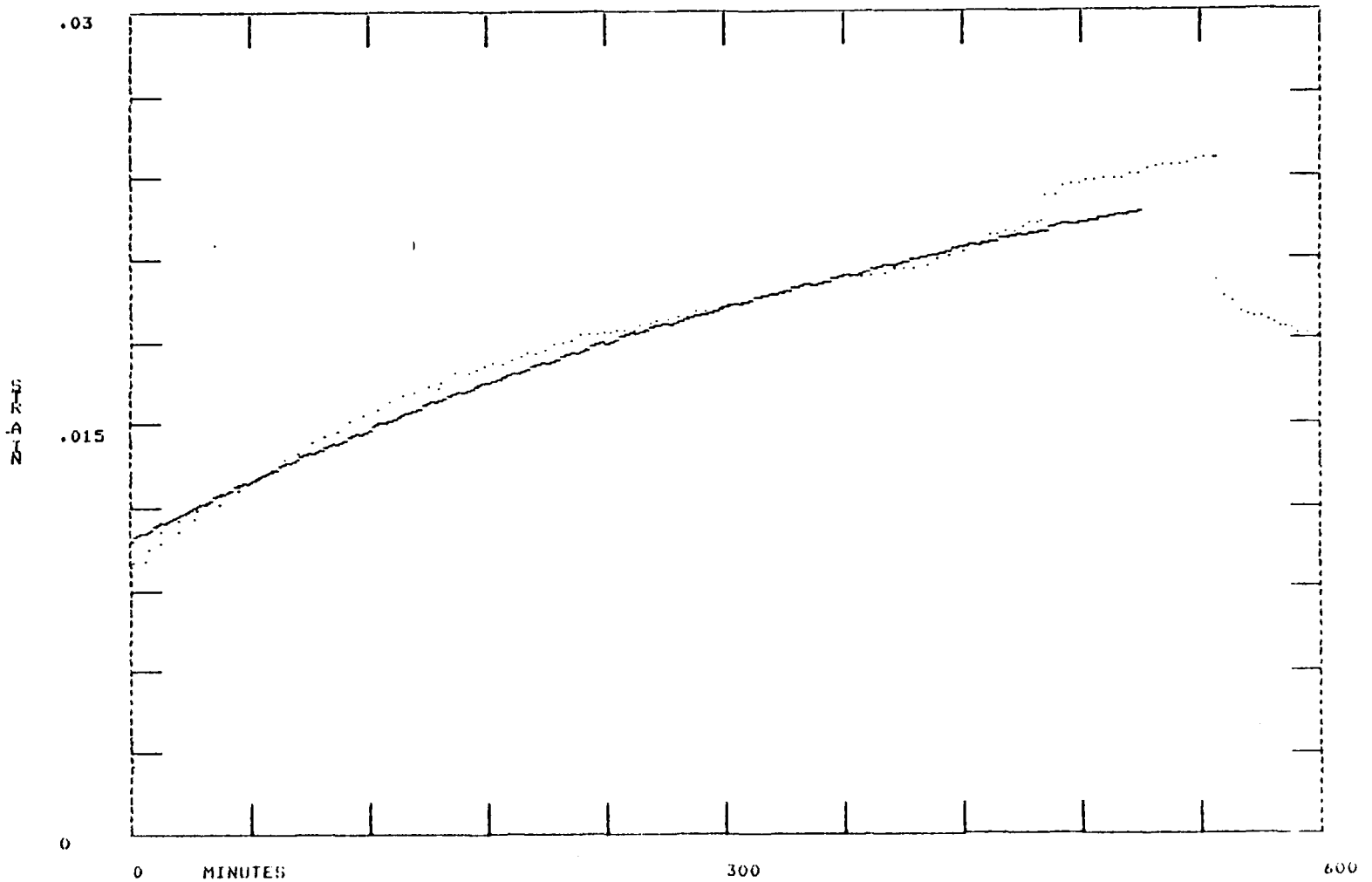
LS 64 17-18 7 MAR 75 AREA = 13.69 SQ CM HEIGHT = 2.66 CM
DOTTED LINE: ORIGINAL DATA HEAVY LINE: MODEL PREDICTION



2-PARAMETER SOLID MODEL WITH VALUES OF
A1 = .020895, B1 = .010113

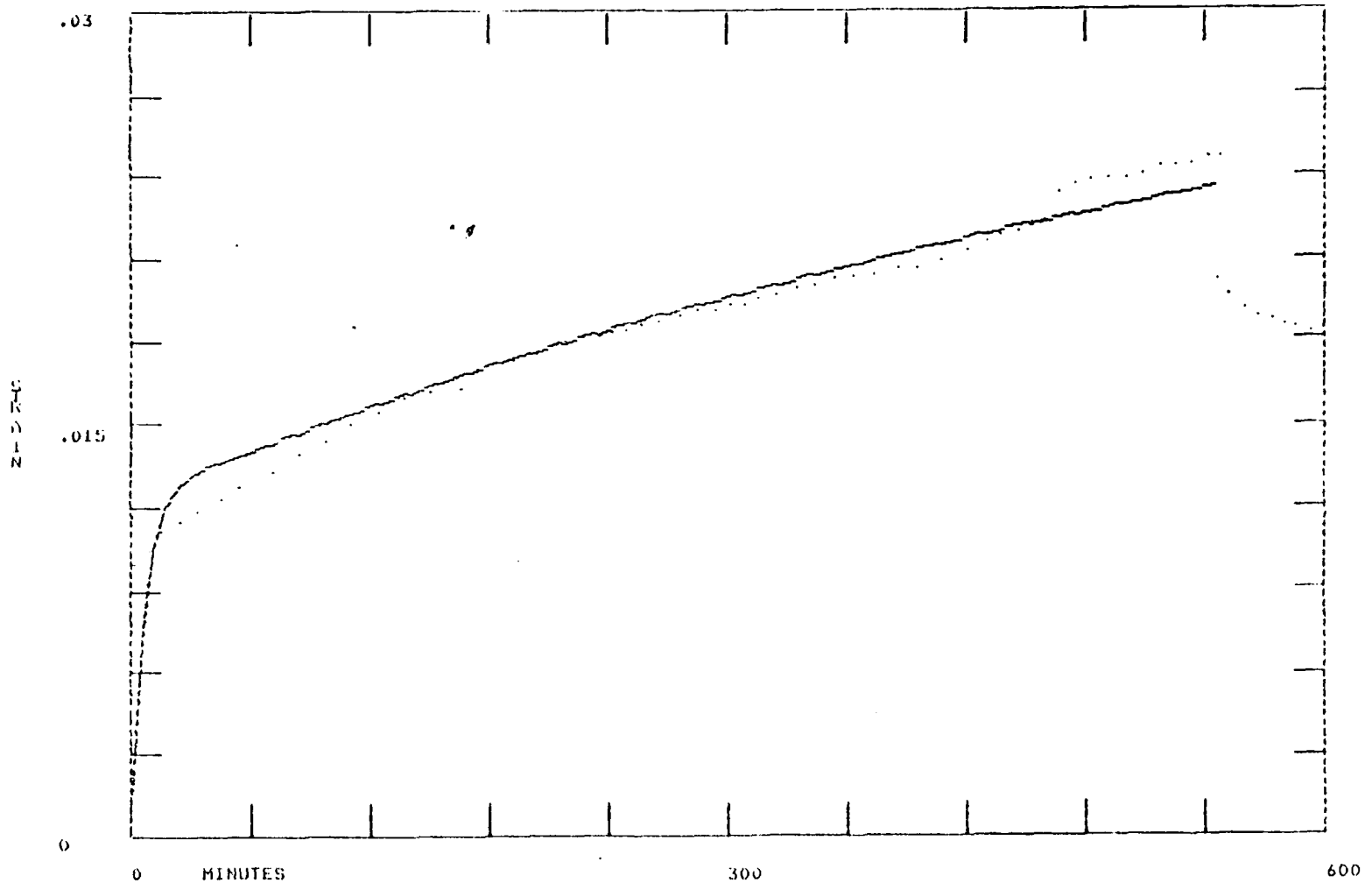
DELTA TIME = 8
ERROR (USING ALL POINTS): 4.295%
ERROR (IGNORING FIRST 3 POINTS): 5.2232%

LN-65 T10-T11 10 MAR 75 AREA = 14.56 SQ CM HEIGHT = 2.765 CM
DOTTED LINE: ORIGINAL DATA HEAVY LINE: MODEL PREDICTION



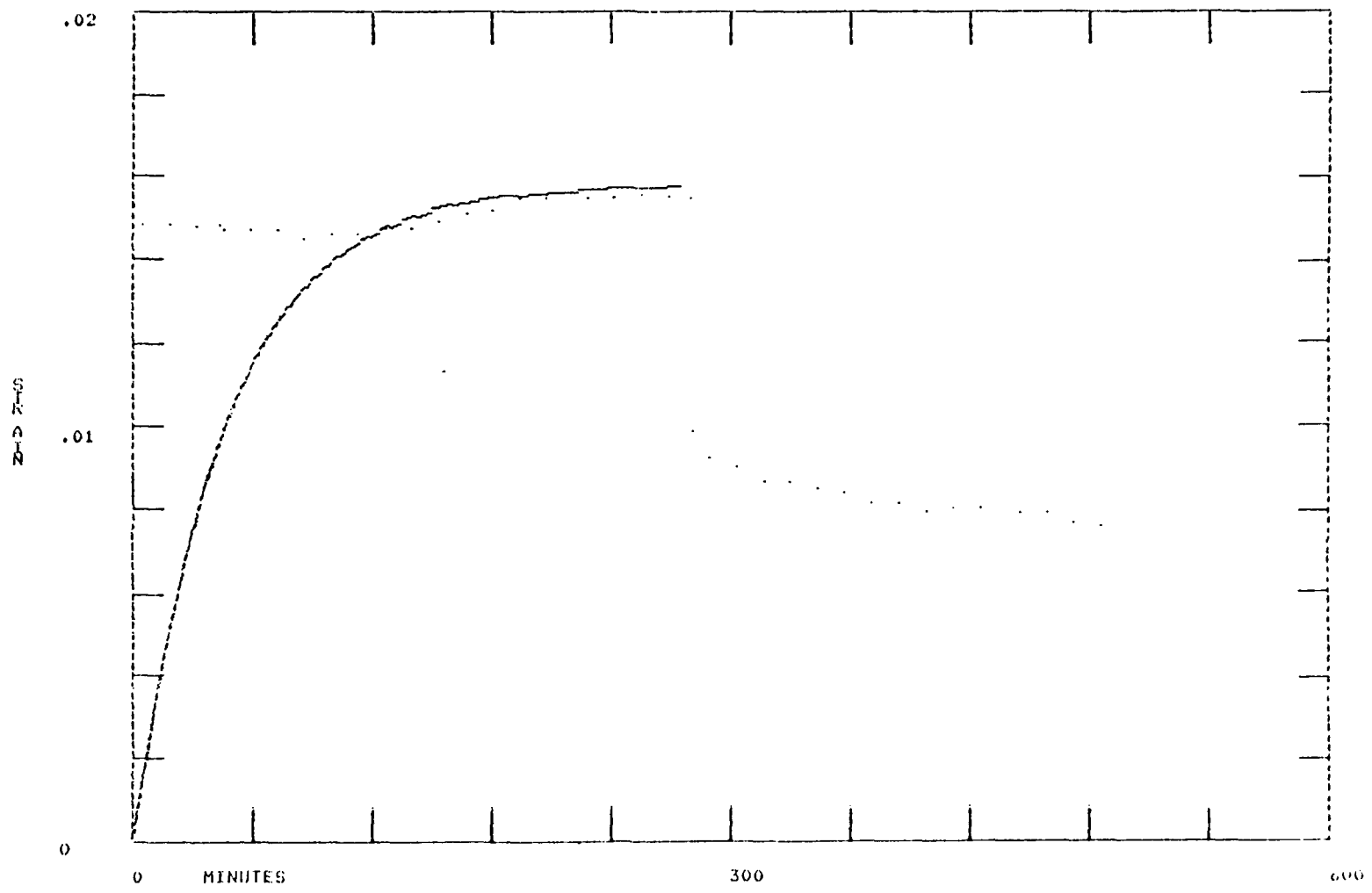
3-PARAMETER SOLID MODEL WITH VALUES OF
A1 = .022309, B1 = 2.0263E-03, A2 = .0108353
DELTA TIME = 4
ERROR (USING ALL POINTS): 0.822%
ERROR (IGNORING FIRST 3 POINTS): 1.513%

LK-65 T10-T11 10 MAR 75 AREA = 14.56 SQ CM HEIGHT = 2.765 CM
DOTTED LINE: ORIGINAL DATA HEAVY LINE: MODEL PREDICTION



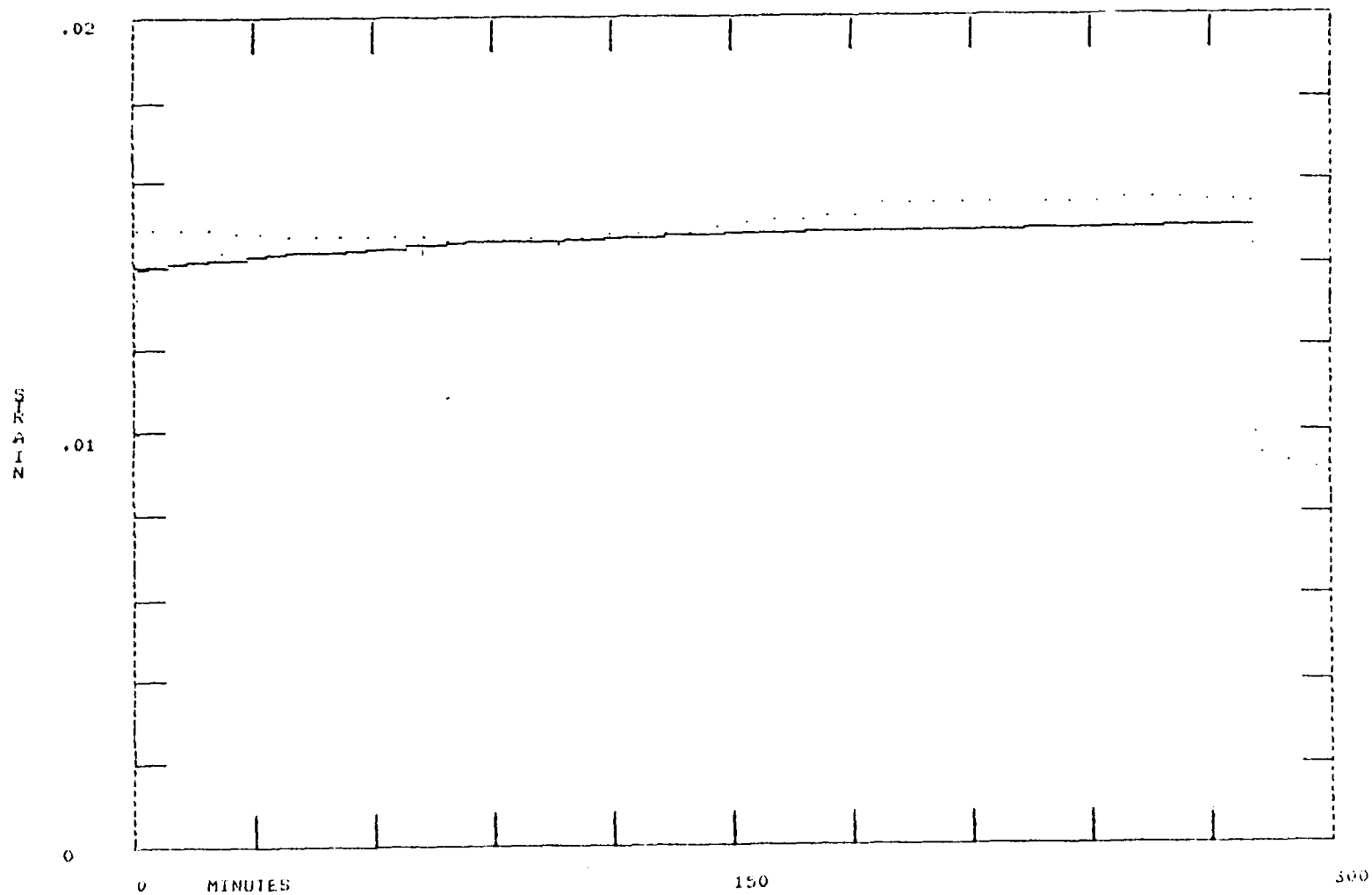
4-PARAMETER SOLID MODEL WITH VALUES OF
A1 = .012379, B1 = .15721, A2 = .020555, B2 = 1.4509E-03
DELTA TIME = 8
ERROR (USING ALL POINTS): 0.374%
ERROR (IGNORING FIRST 3 POINTS): -0.365%

LK-65 T10-T11 10 MAR 75 AREA = 14.56 SQ CM HEIGHT = 2.765 CM
DOTTED LINE: ORIGINAL DATA HEAVY LINE: MODEL PREDICTION



2-PARAMETER SOLID MODEL WITH VALUES OF
A1 = .015807, B1 = .022706
DELTA TIME = 30
ERROR (USING ALL POINTS): 17.182%
ERROR (IGNORING FIRST 5 POINTS): 8.8926%

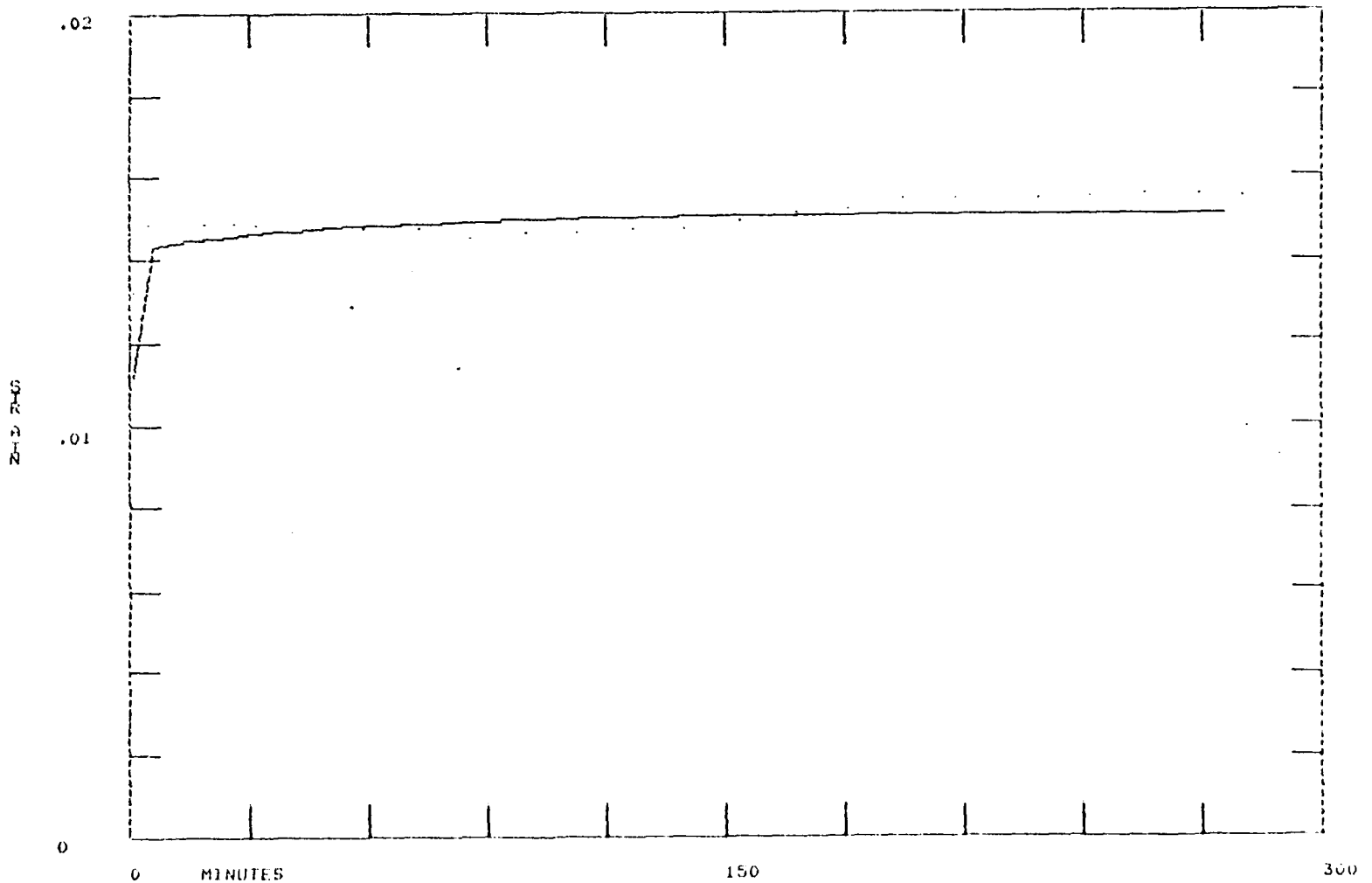
LK-66 TO-T9 11 MAR 75 AREA = 16.33 SQ CM HEIGHT = 2.705 CM
DOTTED LINE: ORIGINAL DATA HEAVY LINE: MODEL PREDICTION



3-PARAMETER SOLID MODEL WITH VALUES OF
A1 = .0155015, M1 = 8.95332E-03, A2 = .0140333
DELTA TIME = 4
ERROR (USING ALL POINTS): 2.5836%
ERROR (IGNORING FIRST 3 POINTS): 2.5902%

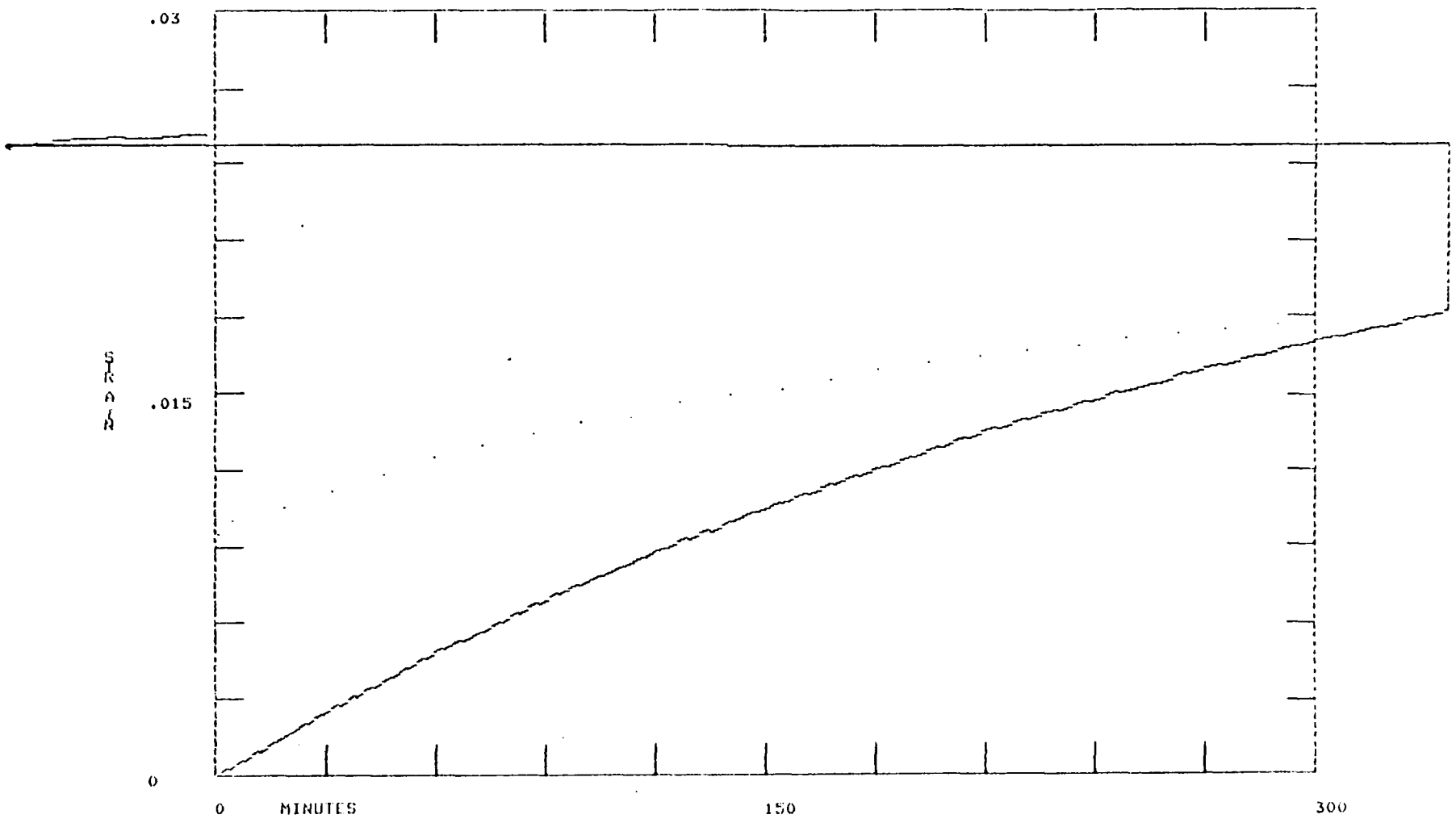
LX-66 T8-19 11 MAR 25 AREA = 16.33 SQ CM HEIGHT = 2.705 CM
DOTTED LINE: ORIGINAL DATA HEAVY LINE: MODEL PREDICTION

127



4-PARAMETER SOLID MODEL WITH VALUES OF
A1 = 8.1631E-04, B1 = .01292, A2 = .014229, B2 = 1.544
DELTA TIME = 4
ERROR (USING ALL POINTS): 2.255%
ERROR (IGNORING FIRST 3 POINTS): 0.244%

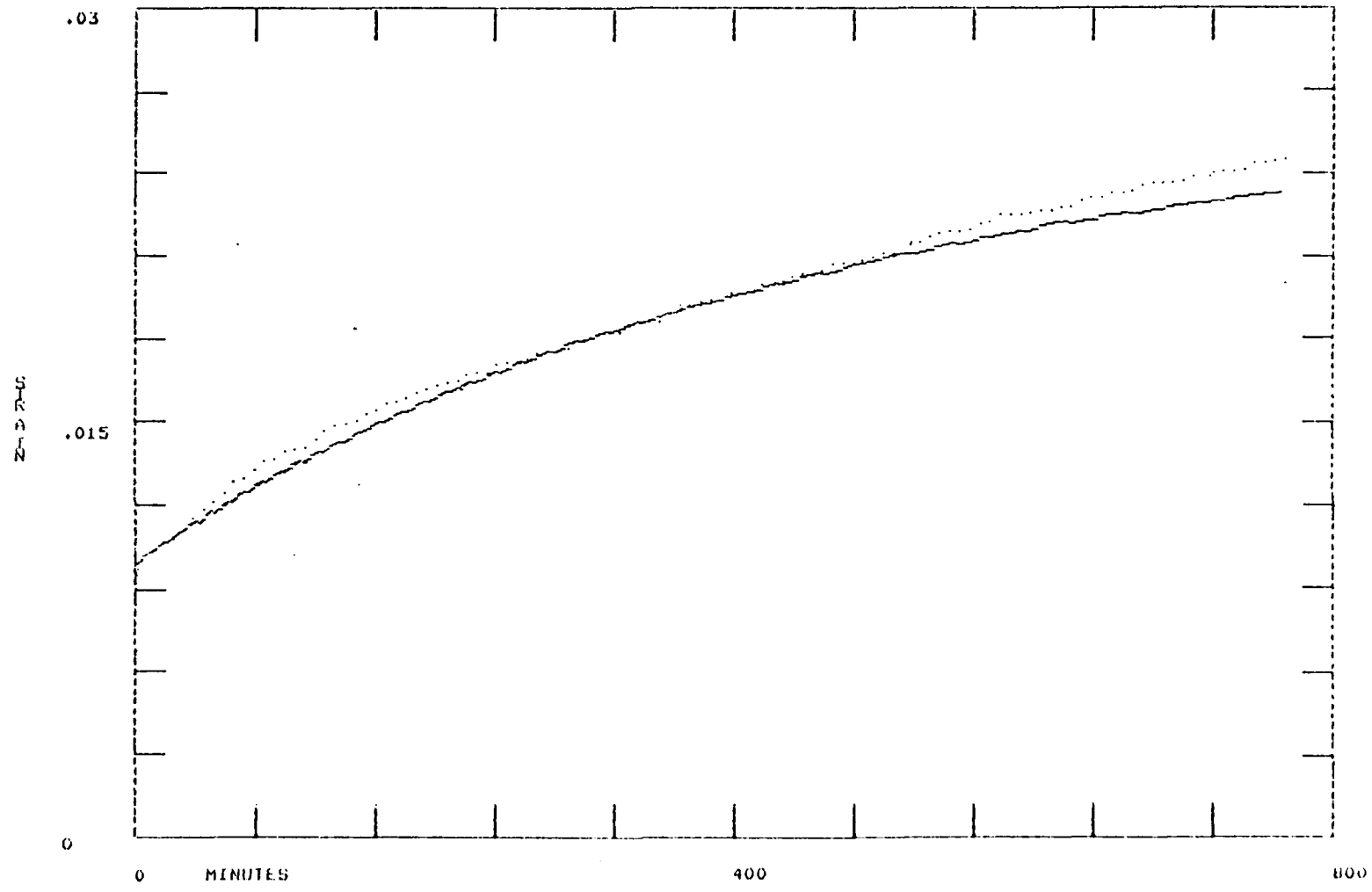
LK-66 T8-T9 11 MAR 75 AREA = 16.33 SQ CM HEIGHT = 2.705 CM
DOTTED LINE: ORIGINAL DATA HEAVY LINE: MODEL PREDICTION



2-PARAMETER SOLID MODEL WITH VALUES OF
A1 = .022708, B1 = 3.15646E-03
DELTA TIME = 4
ERROR (USING ALL POINTS): 35.021%
ERROR (IGNORING FIRST 3 POINTS): 30.734%

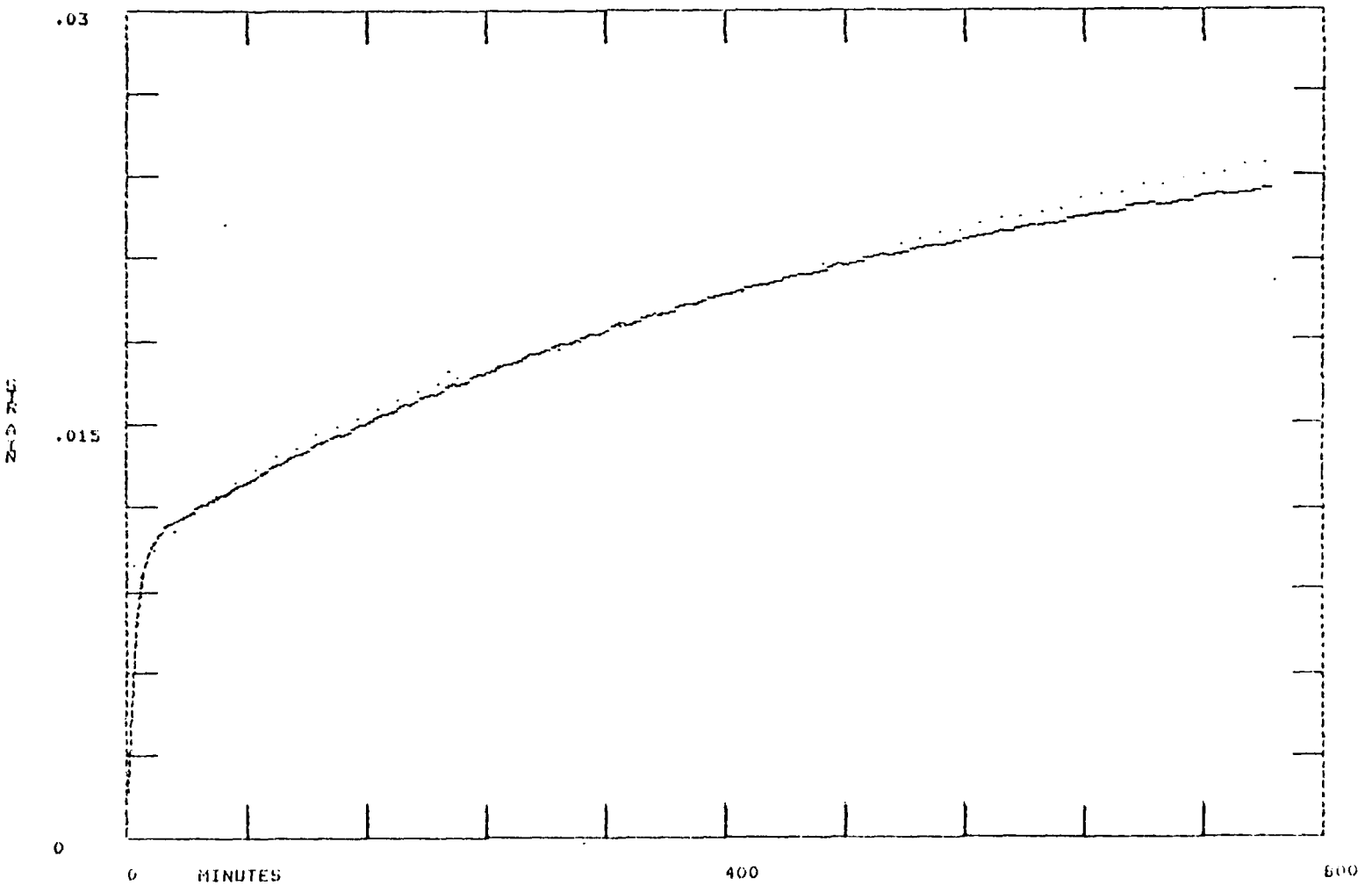
LR 68 112 11 13 MAR 75 AREA = 16.5 SQ CM HEIGHT = 2.935 CM
DOTTED LINE: ORIGINAL DATA HEAVY LINE: MODEL PREDICTION

127



3-PARAMETER SOLID MODEL WITH VALUES OF
A1 = .0226246, B1 = 2.25622E-03, A2 = .010019
DELTA TIME = 4
ERROR (USING ALL POINTS): 2.1234%
ERROR (IGNORING FIRST 3 POINTS): 2.1359%

IN-60 T12-11 13 MAR 75 AREA = 16.5 SQ CM HEIGHT = 2.935 CM
DOTTED LINE: ORIGINAL DATA HEAVY LINE: MODEL PREDICTION



4-PARAMETER SOLID MODEL WITH VALUES OF
A1 = .015528, R1 = 2.017E-03, A2 = .010563, B2 = .20099

DELTA TIME = 4
ERROR (USING ALL POINTS): 2.683%
ERROR (IGNORING FIRST 3 POINTS): 1.442%

LN-68 112-11 13 MAR 75 AREA = 16.5 SQ CM HEIGHT = 2.935 CM
DOTTED LINE: ORIGINAL DATA HEAVY LINE: MODEL PREDICTION


FILME
8